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ASPECTS OF BIOLOGY IN GENERAL SCIENCE AND THE AIMS TO BE ATTAINED.[1]

BY E. F. VAN BUSKIRK, M. A.,

Lecturer, Teaching of Hygiene, University of Cincinnati and Executive Secretary, Cincinnati Social Hygiene Society.

Most boys and girls never take more than one course in science. Until recently this course has usually been devoted exclusively to one special field. The main reason for advocating General Science as an introductory course is the fact that no one of the special sciences is justified in claiming for itself such distinction as is implied in permitting it to make up the whole subject matter of such a course. Thus, making provision for a General Science course is justified from the viewpoint of those who will never take any further work in science. It is also for the best interest of those who will continue their science study. This is because the Junior High School age is the best period for testing out the "interests, aptitudes and abilities" of the boys and girls so that wise choices may be made of their later work. A well rounded course in General Science offers peculiar opportunities for doing this.

The question as to how much of the study should be biology, physics, chemistry, physiography, etc., should depend upon the carefully considered relative values of possible study of certain phases of these sciences. The happiness and well-being of the child should be the main consideration in making selections. Although General Science must necessarily be made up of specialized sciences, every precaution should be taken not to have them presented as such but in their relations to the every day life of the child. It is an easy matter to make such statements as the above but not so easy to determine methods of putting

[1]Read before the General Science Section, C. A. S. and M. T., Englewood High School, Chicago, November 26, 1920.

them into effect. How can we proceed to attain the kind of information which will determine the relative values of possible subjects for study? There are evidently two groups of people to whom such questions should be referred, namely educators and the children themselves.

As far as educators are concerned, there are three criteria which are helpful in determining the content of General Science courses. First, there is the amount of cultural value which may be obtained. By cultural value is meant such subject matter as forms a part of that general body of information with which the person of good education is expected to be familiar. The second criterion would be the practical importance of the subject considered. The third criterion which might justify inclusion of a subject in a course of General Science relates to whether it is of vitally fundamental importance to an adequate understanding of the cultural or practical work which is to follow. In making use of such criteria it is extremely important for the educator to be broad-minded and open-minded concerning the claims of subject matter in which he himself may not be very much interested.

More important than considering the opinions of educators as to what a General Science course should be is the desirability of consulting the children themselves. Certain it is that the pupils have been very often sadly neglected in this regard. They have had courses imposed upon them, without any special effort being made to consult their interests and desires in the matter. I would invite your attention to two ways of securing the child's point of view.

By making it possible for pupils to undertake what may be called individual projects it is possible to find out where their special interests lie. It is not my purpose at this time to discuss the advantages and possible disadvantages of project teaching. That was taken up in an admirable paper presented yesterday. It is my purpose here merely to invite your attention to one of the outstanding advantages of this method of teaching which gives opportunity for a good deal of initiative on the part of the child.

Another promising method of obtaining the child's viewpoint is to be found in investigations relating to the reaction of the children to courses of study already given. I would especially invite your attention in this regard to certain personal observations which I made during a period of nine years as a biology teacher. The observations were made under the following con-

ditions: The course was given five periods a week and was one year in length. The pupils were in the first year of a four year high school and came from homes widely different in character, the majority coming from the middle and from poorer classes. During the greater part of this teaching experience the content of the course during the first term was largely general biology, with the emphasis upon botany. In the second term the emphasis was upon zoology and human physiology and hygiene. There was included about a month's work upon bacteriology, and disease and its prevention. In addition there was also some work upon the elementary study of eugenics, based upon plant and animal breeding.

In obtaining the information, I asked the pupils at the end of the term to select those topics taken up during the year which they had found to be of greatest interest and to give their reasons for making their selections. Before permitting them to answer this question, we very carefully reviewed the work of the year so that their memories might be refreshed. By far the greatest number of pupils selected work relating to health and disease prevention. There were always a few, however, who selected topics that related to some of the animal and plant forms which had been studied. It was the general experience of the teachers in the department in which I taught to find that there was a much greater interest in the second term's work than in the work of the first term. From talking with teachers of girls, I would conclude that much the same sort of reaction has been evident in their classes, although I think it likely that a somewhat larger percentage of girls are interested in what might be called pure botany or zoology.

From such studies as the one to which I have referred I believe that valuable data can be secured which will help in determining the best possible content of such a subject as General Science. The biologic material which I will suggest as desirable to include in General Science is intended for a course of at least a year in length and five periods per week. It is especially intended for the eighth or ninth years. The biological material presented, I consider to be a minimum amount of subject matter which it would be well to include in practically all General Science courses. The needs and interests of the children in different communities will of course vary and additional material and possible eliminations may properly be made to meet the peculiar situations presented in any locality. Furthermore, the suggested

outline for a part of a course in General Science is not intended to be used necessarily in the order given. Certainly it would not be best to arrange to have it given consecutively in a course but rather different aspects of the study would present themselves in connection with topics which might not be biological in their nature at all. Thus, for example, the study of the physiology and hygiene of breathing might be related to other things besides biological topics; such as drafts of stoves, combustion engines, aeroplanes, etc. In other words, the order of topics in the course should not be grouped according to an adult viewpoint into sections of specialized science, but rather the topics should be brought into relation with the life and interests of the child.

One of the biological phases of study which might very well be made to occupy at least a month's attention during the year is general biology. Under this heading there would come up for consideration the following topics:

(1) A study of the cell as the unit of structure and the beginning of life.

(2) A study of life requirements namely air, water, food and favorable temperature.

(3) A study of life activities, respiration, motion, sensation, digestion, assimilation, excretion and reproduction.

(4) Natural biologic resources and their conservation.

Another phase of biology which should be treated in General Science concerns human physiology and hygiene. In this study there should be a practical application of some of the topics listed under the heading of general biology. Much of this material would be very practical in its nature and most of it would also be cultural. It seems that at least one month should be spent upon this subject.

Still another phase of biology which should be included in General Science is an elementary study of disease and its prevention. It would be necessary to study the agents causing some of the most common diseases, the way in which these agents are spread and how the diseases may usually, if not always, be avoided. It would be well to spend time in studying how some few typical health campaigns have been conducted. It is also very desirable for the pupil to know about the work of some of the great benefactors of mankind who have made contributions along these lines such as Jenner, Koch and Pasteur. Again, it would seem that a month would be needed in order to do these subjects justice.

The last topic to which I will refer as being one which should be included in the course has to do with eugenics. A week can profitably be spent in studying the factors involved in plant and animal breeding and applying these principles in a common sense way to the human race. In a very elementary way there would be brought out in such a study worthwhile ideas concerning the continuity of life and the obligation of the individual to see to it that the stream of life would not be polluted through any action on his part.

Considerable emphasis in the material suggested for study has been placed upon practical topics, especially those relating to health. While there is excellent reason to believe that this emphasis is desirable, nevertheless it must also be recognized that much of the subject matter which may be presented will be forgotten. Thus, while we believe that it is important to study such subjects as the care of the teeth, rules for avoiding indigestion and constipation, rules for bathing and the care of the eyes, ears and nose; and while we recognize the importance of studying how to guard against sickness and in general how to observe the laws of health, we must not forget that our duty is not performed unless we accomplish something much bigger and more important than merely imparting information, no matter how practical that information may be. The incidental results of teaching—the by-products so to speak—are often of the greatest significance. Unless our teaching inspires to better living and makes a definite contribution to the molding of character by means of establishing wholesome channels of thought and action, we shall have failed to accomplish our greatest responsibility.

Our teachings should definitely result in helping to establish right attitudes of mind which will be of invaluable worth both to the individual and to society. A pupil should come to have a wholesome respect for law and order through his study of general science. He should be made to feel very deeply that he is no exception to the general operation of the laws of nature, an attitude of mind which may be observed even among some otherwise well educated adults. This can be accomplished through such a study as eugenics and through the consideration of the need of conserving the natural biologic resources of the country for the welfare of the future generations. Such studies should make a definite contribution toward a spirit of altruism.

There is great need for the General Science teacher definitely to give adequate recognition to the fact that there are two

great impelling life forces, namely the hunger instinct and the sex impulse, and that both these forces need education, control and direction. The former topic has received much the greater amount of attention; whereas problems of sex, although they have just as natural and proper a place, have been very largely avoided. It is for this reason that I desire to stress the subject of sex education in this paper.

It was my experience as a teacher in New York City to find that the boys in the first year of high school needed instruction of this kind and that when they received it they did so seriously and with a great deal of gratitude. As already indicated, I often asked boys upon completing the year's course in biology to select the topic or topics which they had found most interesting and worthwhile. Invariably between twenty-five and fifty per cent or more selected subjects relating to sex education. If this is a typical experience—and many teachers will testify that it is—and if we are to accept the principle that the reaction of pupils should be considered in determining the content of a General Science course, it would necessarily follow that such courses should include carefully selected sex educational material.

In order that any teacher may make a contribution to the field of sex education it is first of all requisite that he himself should have a wholesome attitude toward sex in life. He should recognize the fact that the role played by sex in the history of mankind has been of the greatest significance. Such facts as the following should be kept in mind. The family life and all that it signifies has its origin in the sex impulse. Parental and conjugal love depend primarily upon sex. Social sympathy and moral action have their origin in this same sex impulse, as well as ethics, aesthetics and art. In other words, he must realize that sex should and does contribute to the highest and best things in life; and that it is only when it is perverted that it leads to unwholesome conditions.

From the statements just made it may be inferred that our ideas regarding the method and the content of sex education, during recent years, have undergone very radical changes. It may be well to enumerate a few of these changes. It was formererly thought that sex education meant merely a presentation of subjects which are disagreeable, such as the topic of venereal diseases. It was formerly thought that doctors were the best qualified persons to impart sex education. Those who had this work in charge acted, at least, as if they believed that sex educa-

tion should be given just at one period in the child's development. It seems to have been a commonly accepted idea that if the teaching could be given in such a way as to frighten the pupils, that was the best proof that it had been successful. No wonder that there has been a violent reaction to such a program! We now know that although such a subject as venereal diseases should often have a place in a well-rounded course, treating, among other things of sex, it is a mistake to over emphasize that topic. In other words, the emphasis should be upon positive and not negative phases of the study. We now know that very often, although not always, doctors are the very last ones who should be called upon to give sex education and that instead of such teaching coming all at one time, the best kind of instruction is that which is given in the home, the school and through other properly constituted agencies at appropriate stages in the individual's development from very early childhood up and into adult life.

As to the content of the teaching, it would necessarily vary according to whether the classes are mixed or segregated according to sex. In mixed classes it is reasonable to suppose that the properly prepared General Science teacher could present the subject of reproduction in a few typical lower forms of life and in such higher forms as flowering plants and fishes. If nothing else, this study would give a vocabulary to the pupils and show them that reproduction is a subject which can be treated in a natural way, the same as any other life activity. Attention should also be given to the subject of plant and animal breeding and eugenics in mixed classes. In segregated classes, providing the teacher is properly qualified, much more can be done. If there is an adequate background relating to the study of disease, venereal diseases, at least in boys' classes, may properly be given a few minutes of attention. Again, upon a fitting background, an elementary study of the physiology and hygiene of the human reproductive organs in its relation to the adolescent boy or girl, as the case may be, has a proper place. There might also be introduced some very elementary work relating to human embryol ogy.

A few significant studies have been made to determine the results of omitting sex education. These studies uniformly show that such lack of information from authoritative sources leads children to acquire information from boy or girl companions and other questionable sources. The result is that precocious inter-

est and heightened curiosity, often leading to unnecessary worry and harmful practices, are aroused. The question that faces leaders of young people is not whether children are or are not to receive information regarding sex but rather whether these leaders wish to take any part in imparting such information. The omission of sex education also is undoubtedly one of the factors preventing a more general acceptance of the single standard of morality. As far as adults are concerned, countless numbers of unhappy homes, many cases of divorce, and the general lack of a public conscience and opinion concerning problems relating to prostitution, feeble-mindedness, illegitimacy and venereal diseases are perhaps the outstanding evidences of a need of sex education.

It should not be inferred from the above statements that it is claimed that sex education will produce one hundred per cent results. There are persons of low grade mentality who cannot be educated. It is reasonable to expect, however, that this kind of education, if wisely carried on, will help many of those who are normal as far as their own actions are concerned and will also assist them in helping to make satisfactory provision for those who are abnormal. The wisdom of establishing new habits of thinking and acting through an educational program must be self-evident to all thinking persons. Thus, such ideas as that it is natural and proper for a young man to "sow his wild oats" and that continence is incompatible with health must be banished. It should be remembered that a normal person's actions depend even more upon established customs and habits of thinking than they do upon natural impulses.

One of the most hopeful signs of the present day is the increasing amount of attention being given to sex education by parents, prominent organizations, and educators. There are two agencies of the Federal Government engaged in helping to make it possible to prepare teachers better to meet such responsibilities. These two agencies are the U. S. Public Health Service and the U. S. Interdepartmental Social Hygiene Board. Many city and state departments of education and health are actively interested in this movement. Several universities and educational institutions are offering courses especially intended to assist parents, teachers and others more effectively to help young people meet problems in sex education which arise in the lives of all normal youth. Much good work has already been accomplished on the part of some of the most competent teachers by including carefully selected sex educational material in their work.

In this paper it may appear to some that I have dwelt unduly upon the subject of sex. In order that my position may not be misunderstood, let me definitely state that I am not advocating a special course upon this subject in the high school but merely indicating some of the ways in which properly qualified teachers of General Science may cooperate with parents in helping young people solve for themselves some of their most important life problems. Certain it is that those courses are most worthwhile which help interpret life sanely and wisely. We would probably all agree that regardless of whether the teaching relates to sex or not, it should have a moral effect in the upbuilding of strong character. This is indeed the ultimate aim of all education. As a result of his General Science course, the child should be more thoughtful of others and be better prepared to make wise choices of conduct to the end that he himself may be happier and at the same time make the world a little better for having lived in it.

PROJECT TEACHING IN GENERAL SCIENCE.[1]

BY G. H. TRAFTON

Normal School, Mankato, Minn.

The first step in the discussion of any subject is to reach a general understanding of what the topic means. Unfortunately there is no general agreement as to what a project in education is. A study of the current literature on the subject shows a great diversity of usage of the term. It is a very common topic for discussion in educational circles; but until there is more agreement than at present exists, there is bound to be continued confusion. It is not the writer's intention to add to the confusion by suggesting another definition, but rather to try and clarify the situation by finding the similar elements that underlie the various definitions.

One cause of difficulty lies in the attempt to explain one's position in brief sentence definitions. The project is too comprehensive a subject to permit of being confined in any such limits. In some cases the word is used carelessly without any conception of what it means.

Among those who do use it in a definite sense are some who use it as another word for topic. Such headings as air, water,

[1]Read before the General Science Section of the C. A. S. and M. T., Englewood High School, Chicago, November 26, 1920.

and food are called projects. At the other extreme are those who use it in the very limited sense of applying it only to activities of the manual training type, such as the construction of a bird house.

But outside of these extremes there seem to be certain principles underlying the use of the term project which tend to suggest some agreement and make the confusion of terms more apparent than real. Instead of quoting mere formal definitions of the word project, a better conception of what the authors mean by the term will be gained by noticing some of the characteristics that a project should possess.

David Snedden writes: "The following were the primary characteristics of projects as thus conceived: (a) the undertaking always possessed a certain unity; (b) the learner himself clearly conceived the practical end or outcome to be attained, and it was always expected that this outcome was full of interest to him, luring him on, as to a definite goal to be won; (c) the standards of achievement were clearly objective, so much so that the learner and his fellows could in large part, render valuable decisions as to the worth—in an amateur or in a commercial sense—of the product; and (d) the undertaking was of such a nature that the learner, in achieving his desired ends, would necessarily have to apply much of his previous knowledge and experience—perhaps heretofore not consciously held as usable in this way—and probably would have to acquire also some knowledge and skill."

C. R. Mann writes: "A project is characterized by (1) a desire to understand the meaning and use of some fact, phenomena or experience. This leads to questions and problems. (2) A conviction that it is worth while and possible to secure an understanding of the thing in question. This causes one to work with impelling interest. (3) The gathering from experience, books, and experiments of the needed information, and the application of this information to answer the questions in hand."

J. A. Stevenson writes: "(1) The project implies an act carried to completion as over against the passive absorption of information. (2) It develops the problematic situation demanding reasoning rather than merely the memorizing of information. (3) It implies by emphasizing the problematic aspect, the priority of the problem over the statement of principles. (4) It makes provision for the natural setting of problems as over against an artificial setting."

Projects in Agriculture. The U. S. Department of Agriculture has developed a plan for home projects in agriculture. In a bulletin published by the department seven requisites are given for the carrying out of a home project. Four of these relate to the method of carrying out the project. The following three suggest some of the principles involved in the project: "(1) There must be a plan for work at home covering a season more or less extended. (2) It must be a part of the instruction in agriculture of the school. (3) There must be a problem more or less new to the pupil."

Principles Underlying Projects. Two principles seem to the author to underly most of the discussion of projects. The first principle is that the child shall be engaged in some activity (either manual or mental); and the second is that this activity shall be motivated through the child's own desire to do the thing because it appeals to him as worth while. The motive is internal not external. *Properly motivated activity* seems to be the central concept underlying the use of the word project.

From this standpoint, then, a project simply means the application of modern pedagogy to teaching. The law of self-activity as an essential to learning needs no exposition here. The emphasis now being placed on the project means that the child is coming into his own in the school. It means the recognition of the principles that both the content of the school curriculum and the method of teaching should be determined by the needs and interests of the child and not by the subject matter or by the adult. It has long been recognized that the method of teaching must depend upon the child, but slower recognition has been given to the equally evident principle that the content of the school course must also be determined by the child's needs and interests.

The project represents a spirit in teaching, which may extend to all lines of school work. It means the injection of the child's interests into school as the directing force in which the impelling motive comes from within. To the writer the fundamental thing is not to be sought in the details of what is done and how it is done, but rather in the fact that we are applying the sound pedagogical principle that the pupil is being guided by his own natural, innate interest, which has been aroused to carry on the work in hand.

The application of these principles means the breaking away from the old, but still prevailing, organization of the schools on

the basis of subjects, in which geography, science, history, etc., are taught as separate, disconnected subjects. It recognizes that organization from the child's standpoint demands that the school work shall be centered around the activities of the child, not around separate subjects. The following out of these activities may lead into many fields. The project method makes a vertical cleavage across the school studies instead of a horizontal one, which the old organization requires.

The project naturally leads to the psychological rather than to the logical organization. In the psychological organization the unity in the project lies in the relation of the facts to the guiding purpose, not in the relation of the facts to each other (the logical organization). The first relation leads to power, the second to formal organization. The first leads towards life activities, the latter leads away from them.

In accordance with the broad conception of projects here outlined it will be seen that the project method may be applied to almost any line of school work. It represents an ideal, a method, the best method of teaching. As it represents the application of sound pedagogy to teaching, efforts should be made to make all school work project work. It does not represent any special kind of work but rather a special method of working. A project is not merely a topic, and it cannot be confined to manual activities alone. It must also include many mental activities in which no manual work in involved.

Perhaps one cause of confusion in the use of the term lies in the fact that two people may use the word project to apply to different lines of activity, and both may be correct; but neither sees that the other one is correct also. The difficulty lies in the narrow conception each has of what constitutes a project. It is perfectly proper to call the making of a desk a project, but this does not preclude calling also a project the study of books to find out why the United States entered the war. In other words, there are many kinds of projects. Variety must naturally follow from the principle of purposeful activity. As children have many purposes in life, so projects may present a variety that corresponds with the variety of purposes.

We may obtain a clearer idea of what may constitute projects in school by thinking of some projects that engage the attention of both children and adults in life outside of school. Following are just a few out of many: To learn how to drive an automobile; to make a toboggan; to learn how to swim; to organize a baseball

team; to prepare a paper to read at a gathering of teachers; to raise vegetables for home use; to make a collection of postage stamps; and so on indefinitely. A study of life activities is always profitable when studying school problems. If any one of these or other projects be followed out, it will be found to lead into many diverse fields; and when the project is finished, the whole thing represents to the doer a unit that is full of meaning. Organization around projects is the natural thing in life. Projects guide our activities and give meaning to life.

Types of Projects. There may be a great many types of projects according to the number of pupils involved, the place of execution, the activity involved, and the complexity of the project. This classification may be put in outline form as follows:

TYPES OF PROJECTS

1. Number of pupils involved.
   - A. Individual project:
     - To raise vegetables in the home garden.
   - B. Group project:
     - To form a league of Modern Health Crusaders.
2. Places of carrying on projects.
   - A. Home project:
     - To study the heating system of our homes.
   - B. School project:
     - To see if the schoolroom is properly ventilated.
   - C. Community project:
     - To investigate the public water supply.
3. Environment in which carried on.
   - A. Laboratory projects:
     - To show the effect of light on certain salts of silver.
   - B. Outdoor project:
     - To identify the weeds found growing in the garden.
4. Relative importance.
   - A. Major project:
     - How may birds be attracted around the home?
   - B. Minor project:
     - What kind of a necting house should be made for a pair of house wrens?
5. Activity involved.
   - A. Construction project:
     - To make a nesting house for the bluebird.
   - B. Observation project:
     - To see how many times a pair of birds feed their young in an hour.
   - C. Investigation or intellectual project:
     - To learn why birds migrate.

Attention may be called at this time to the fact that General Science offers a great variety of projects which deal with concrete materials. This type of project appeals especially to boys and girls of the Junior High School age. It is fitting that General Science should pay special attention to this type of project. The author refers to what is commonly called laboratory and field work. When properly carried on, this represents a

valuable line of projects. In the laboratory we may distinguish two types of work, the observational type and the experimental type. The observational type is illustrated by biological studies, as of insects and flowers. The experimental type is illustrated by physical studies, as of magnets and air pressure. These may be carried on as individual studies or as demonstrations. Whether an exercise shall be carried on as a demonstration or as an individual study depends on several factors, such as the equipment at hand and the nature of the exercise.

An appreciation of the great variety of projects possible may help to clarify the situation and lessen the confusion now existing regarding the use of the term project. The word project should not be limited merely to the practical type of laboratory and field work done in science. There are many other types of projects of the intellectual kind in science. Furthermore the project method can be applied to all subjects in the curriculum, in some of which little or none of the practical work so common in science is possible.

Projects and Problems. Some writers make a distinction between a problem and project, and others do not. To the writer the terms seem so nearly synonymous that it is not worthwhile to attempt to distinguish between them. The ideas back of the problem and project methods of teaching are essentially the same.

So far as there may be a minor difference, it would seem to be merely in the form of statement. A problem may usually be stated in the form of a question, while the project may often be introduced by an infinitive, suggesting perhaps more fully the idea of doing something. For example, under the topic bird houses, we may have the problem, "What kind of a house should be made for the wren?" The same idea in the project form may be stated as follows, "To make a house suitable for the wren." So far as there is a difference, it might be simply that the project suggests more definitely the activity involved. But on the whole the author does not believe it worthwhile to attempt to make any fine distinction between these two words. To do so would only add needlessly to the confusion. A teacher who is using the problem method of teaching is using the same fundamental principles as the teacher who is using the project method.

Project versus Topic. But the author cannot agree with those who make the word project synonymous with topic. To call a topic a project is to deprive the term project of its educational value. A topic is a lifeless thing suggesting neither purpose nor

activity. For example, in various books the author finds the following given as projects: The earthworm, fruits, food, life, matches, wells, tomatoes, and so on. Each of these topics may suggest scores of projects, but is not in itself a project.

Following are some of the differences between topics and projects as they stand out in the writer's mind: A topic is simply a large unit that suggests no line of activity, while a project suggests the doing of something. For example, air is a topic. "To learn of what air is composed" is a project relating to air. A topic suggests no motive to impel pupils to activity, while a project furnishes such a motive. A project furnishes a basis for the selection of facts according to value, while a topic furnishes no such basis. A project suggests more of the human relationships than does the topic. A project suggests a question or problem demanding a solution, a topic makes no such challenge. A topic tends to throw the responsibility for thinking on the teacher, while the project tends to throw it on the pupils.

From the preceding discussion it will be seen that General Science lends itself admirably to project teaching. The factors that we have been discussing as involved in projects are proper motivation and self-activity. As a result of the applications of these principles there is a consequent cutting across the old organization according to subjects. General Science represents a movement to cut across the old classification into special sciences, and represents a new organization in which the distinction between the special sciences is broken down, just as a project would naturally demand. Thus naturally General Science offers an excellent field for project work. General Science projects are easily motivated because science touches the child's life in so many ways. The subject deals so largely with concrete things that it offers opportunities for many manual activities, which make an especially strong appeal to children of the Junior High School age.

The following projects are given as suggestions of what may be done in general science in field and laboratory work.

PROJECT I.

Major project. To see what advantages each of the following methods of heating our homes possesses: hot air, hot water, and steam.

Minor projects.

A. Home project:
   a. To make a study of the heating system used in one's home.

B. Laboratory projects:
   a. To prepare oxygen and study its properties.
   b. To study the burning of wood, soft coal, and hard coal.
   c. To compare safety and ordinary matches.

C. Demonstration projects:
  a. To study the principles applied in the hot air furnace.
  b. To study the principles applied in hot water heating.
  c. To learn the source of heat in the steam heating system.

PROJECT II.

Major project. Which is the most valuable use that can be made of electricity in the home?

Minor projects.

A. Demonstration project:
  To show the effect of electricity in heating a wire.

B. Laboratory projects:
  a. To study the working and construction of an electric bell.
  b. To make a simple wet cell.
  c. To see how the cells used to operate door bells are made.
  d. To study the parts of an electric lamp and see how a mazda lamp differs from the old incandescent lamp with carbon filaments.
  e. To compare the cost of electricity in using the different kinds of lamps.
  f. Does it cost twice as much to run a 100 watt lamp as it does to run a 50-watt lamp?

C. Home projects:
  a. To see how the parts of an electric door bell outfit are connected.
  b. To repair the door bell if it gets out of order.
  c. To read the electric meter and compute the cost of electricity for a month.
  d. To learn how much it costs to run each of the following for an hour: (1) electric toaster, (2) coffee percolator, (3) iron, (4) oven, (5) lamp.

Following are suggested a few projects of this type:

PROJECTS PERFORMED OUTSIDE OF SCHOOLROOM.

1. Home projects:
  A. To read the gas meter and learn the weekly cost of the gas used.
  B. To store eggs for winter use.
  C. To beautify the home by means of house plants.
  D. To raise early vegetables.
2. Community projects:
  A. To investigate local conditions with reference to the water supply.
  B. To learn how the class can help control the fly nuisance.
  C. To see if our shade trees are being properly cared for.
3. Field projects:
  A. Nature trips:
    a. To learn to name some of the common constellations of stars.
    b. To learn what beneficial birds are common in your locality.
    c. To study those shrubs and vines that are adapted for growing in the home grounds.
  B. Industrial trips:
    a. To visit the central telephone office.
    b. To visit a moving picture theatre to see how the projecting apparatus works.

In concluding I wish to call attention briefly to the value of those projects that may be done outside of the schoolroom. The greatest value of this type of work lies in the fact that it connects the school work with real life, because these studies are made under life conditions. In the second place, this type of work solves the problem of the expense involved in securing apparatus. This work requires no special apparatus because it takes things as they really are and studies science in life as it exists in the child's home and in the community.

THE VALUE OF ECOLOGY IN THE INTERPRETATION OF FOSSIL FAUNAS[1].

By Frank Collins Baker,

Curator, Museum of Natural History, University of Illinois.

The interpretation of the extinct faunas that lie buried in the earth's strata has engaged the attention of many students. One who attempts to unravel the mysteries of these buried records must have both imagination and inductive powers. From the remains of animals and plants in these strata, often largely fragmentary, the student must build up, bit by bit, a picture of the animal and vegetable life that existed during this period, the kind of an environment in which these biota flourished, and the general character of the climate.

As an example of this kind of interpretation, I may mention the underlying rock of Chicago. This limestone is believed to have been deposited in a sea that covered a large part of the middle west. It was shallow and the temperature was relatively high. These facts are indicated by the presence of reef-building corals, which can only live in comparatively shallow water and in a warm climate like Southern Florida.

. It is to the interpretation of more recent faunas, however, that I wish to direct your attention at this time, faunas buried during the last great geological period known as the Pleistocene or Glacial Period—the Ice Age. In such interpretation the science of ecology is absolutely indispensable and without such aid grave errors may be made.

Chicago furnishes one of the best striking examples of the value of ecology as an aid in the interpretation of these more recent faunas. In the northern part of the city, and extending northward to Wilmette, there once existed a large embayment of glacial Lake Chicago, the precursor of the present Lake Michigan. In this old lake bed there are many strata, superimposed, which contain the remains of life that once lived in this bay. Without a knowledge of the modern or recent ecology of fresh water life it would be impossible to interpret these strata and rebuild the faunas as they were in life during the several changes that took place in this locality during the retreat of the great ice sheet and the final forming of the great lakes.

Ecology applied to the fossil remains in these strata tell us that this bay was at first a part of the open lake without life,

[1]Contribution from the Museum of Natural History, University of Illinois, Number 15 Read before the Ecological Society of America, Chicago, December 28, 1920.

the waters being cold and the environment unfavorable; that there followed a period of low water when the bay was protected from the rough waters of the lake by a bar or off-shore barrier, and a fauna of swamp or shallow water forms of life occupied the shallow bay. This is indicated by the presence of such snails as *Galba*, *Planorbis*, *Physa*, of species that today are found only in swamps or shallow water ponds and lakes. That the climate was cold is attested by the presence of such species of trees along the shore as spruce, tamarack, fir, and arbor vitae, which are now to be found in regions considerably to the north of Chicago.

Above this fauna a heavy bed of sand and gravel was laid, indicating a rising water body and over this stratum, in some places two feet in thickness, there developed a large fauna of river mussels of species that now inhabit our large rivers, indicating that the water was deeper than in the previous stage and that the bay was more open and subject to some wave action. There is a total absence of the fresh water pulmonates so common in the previous stage. These naiades must have been brought to this habitat by the aid of fish, in the glochidial stage, and liberated from the cysts when the fish reached this bay.

A third stage follows the unionid fauna in which the bay became shallower and the water muddy. There is here a total absence of the river type of naiades and a return to the fresh water pulmonates of the swamp and shallow pond type. A fourth stage indicates a return to deeper water with a sandy silt bottom inhabited by a few cyclads and gill-bearing gastropods and some fresh water pulmonates. A fifth stage was probably a land surface, strikingly indicated by the presence of crawfish burrows which are covered by succeeding deposits. A sixth stage indicates a shallow bay inhabited only by a few cyclads, gill-bearing gastropods, and fresh water pulmonates. The last, or seventh stage, is the present, which is a land surface with a few small ponds and swampy streamlets.

We have here, then, a succession of geological strata filled with animal and vegetable remains of life which can be correctly interpreted only by one having an extensive and varied acquaintance with the same animals as they are found today. With such knowledge a perfect picture of the ecology of this ancient bay can be drawn, the plant and animal communities in the different strata reflecting accurately the varying physical conditions as the water became shallower or deeper. Without the aid of ecolo-

gy the beds of shells and other remains are utterly without meaning. Such deposits have been noted by geologists and dismissed with the simple statement that "molluscan shells were present," information that tells nothing and leaves one in doubt as to just what conditions prevailed at the time the deposits were formed.

A recent study of the literature relating to glacial deposits, as well as the examination of glacial material containing the remains of life, indicate that many errors have been made by geologists because due attention was not paid to the ecology of the species contained in the deposits examined. Many years ago, Worthen, the State Geologist of Illinois,[2] reported land and fresh water shells from a loess deposit near Alton, Illinois. Recently, material from this locality has been examined and found to contain an abundance of land shells, but no fresh water shells. The presence of a *Succinea* probably indicates the source of the report of fresh water shells. The genus *Succinea* embraces at least two ecological groups which are quite distinct as regards their habitats; one, represented by *Succinea retusa,* is usually found in the vicinity of water, especially the borders of ponds and lakes, where it occurs on emergent vegetation, on the wet margins of the shores, and sometimes actually in the water, where it may have fallen or been forced from some adjacent vegetation; the other group, represented by *Succinea ovalis,* lives in upland regions away from water, and usually in forests of some size. The species at Alton is of the latter or upland type and the associated species, *Polygyra profunda* and *Polygyra multilineata,* are all land mollusks. The deposit is true loess, a fact indicated by the presence of typical land mollusks and the absence of fresh water species.

The interpretation of loess deposits is frequently attended with difficulty if the ecology of the species contained in the deposit is not known and taken into account. A collection recently received for determination contained both land and fresh water species of mollusks, the latter predominating. One not well acquainted with the species and taking simply the fact that they were inhabitants of fresh water (and the loess is said not to contain species of this character) would feel justified in referring the deposit to the action of water. A study of the ecology of the species, however, tells quite another story. Two fresh

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[2]Geol. Ill., I, p. 315.

water species of mollusks were represented by many specimens. These were *Pomatiopsis lapidaria* and *Galba obrussa*. The first is not an inhabitant of lakes or ponds, but of small streams, almost rivulets, a foot or two wide, which usually flow through open forests. The *Galba* inhabits similar situations. The land shell present in this deposit, *Helicodiscus parallelus,* is commonly found in woodlands near such small streams (also found where there are no streams), under started bark, pieces of bark, and other debris.

When analyzed from the ecological standpoint the species are seen to be in perfect harmony with aeolian deposits. The locality from which the material came was once forest covered and a small stream flowed through it inhabited by these small snails. Later, the stream may have become dry, as frequently happens in the autumn, and loess deposits formed, covering up the stream bed and burying the mollusks. With a knowledge of the ecology of the species it is comparatively easy to reconstruct the fauna and build up a picture of the environment.

Much of the old controversy as to whether the loess was water or wind laid was based on the presence of these water snails and even clams, for *Sphaerium occidentale* is common in woodland pools that dry up in summer and may become filled with wind-blown sand and fine particles of soil. Little attention was given by most glaciologists to the precise ecology of the species found in these deposits, which were usually identified by other people and the names used by the geologists working on the problems. If the specialists naming the species indicated that they were of fresh water origin this was sufficient for the worker who built up his theories on this data. The subject of loess fossils and their interpretation as regards the deposits in which they occurred has been ably discussed by Professor B. Shimek, who has given this subject long attention[3].

The above examples are sufficient for my purpose, which is to emphasize the value and importance of ecological studies in the consideration of fossil deposits and their faunas. This is especially true of the deposits laid down during the last geological period—the Pleistocene—and to correctly interpret many of these deposits one must have a wide knowledge of the ecology of the animal life of the temperate and boreal parts of America. The presence of fresh-water shells does not necessarily mean that a lake or river was present when certain deposits were

[3]Science, N. S., XXXVII, pp.501-509, 1913.

formed. It depends entirely upon just what species are present. As has been stated, such mollusks as ***Pomatiopsis, Galba obrussa, Physa gyrina***, or ***Sphaerium occidentale*** indicate that a small swale or woodland pool was present; or perhaps a small rivulet or stream in the forest; river mussels, ***Campeloma***, and ***Goniobasis*** or ***Pleurocera*** would usually indicate a large stream like a river. Sometimes there will be a mixture of both land and fresh-water species, including woodland types of land shells and river types of water shells, and here the deposit would be interpreted as a flood plain of a river in which the land shells (mostly dead and without the animal) had been washed down and mingled with the water shells, which had also been washed down the river by high water or floods.

There is no more fascinating branch of science than the interpretation of the fossil faunas which lived before, during, and after the ice age, and when the knowledge of modern ecology is applied to the species it becomes comparatively easy to reconstruct the biota and to make conclusions as we would from the study of living animals and plants in a modern habitat. The study of fossil faunas is, then, largely dependent upon ecology for their correct interpretation.

RELATION OF SCIENCE AND MATHEMATICS TO BUSINESS AND INDUSTRY.[1]

By Fred D. Barber,

Illinois State Normal University, Normal, Ill.

The Girls' Finishing School or the Girls' Seminary which thrived in New England during the last half of the eighteenth and the first half of the nineteenth centuries well represented one type of education. Latin, French, music, painting, some mental philosophy, logic, some history, and Davies' and Boudon's algebra, and Burrett's descriptive astronomy constituted the usual course of study. The conception was that to be educated—for a girl to be educated, at least—was for her to have acquired a fund of interesting information and a training in the arts which set her apart from those who did not receive such advantages. It was an education for culture. Far be it from me to condemn such an education as valueless. My aged mother, now nearing the ninetieth milestone, was the fortunate recipient of such an education. To the stimulation I received from her in my boyhood days I owe chiefly any aspirations I may ever have

[1] Read before the General Science Section, C. A. S. & M. T. Englewood High School, Chicago, Nov. 26, 1920.

had. I am the fortunate possessor of most of her old textbooks and they are to me a never-ending source of interest and wonder.

There still lingers in some of our higher institutions of learning, especially in the East, some relics of the typical girls' finishing school courses of a century ago. As I look over the courses of study and the enrollment in the various subjects in our modern public high schools, I sometimes think that there are two contending influences at work there: First, there is the tendency to hang on to the old culture studies, on the part of many, for the fear of losing caste and missing scholarship, and second, a tendency on the part of others to cast aside as valueless all culture subjects and substitute training in the mechanic arts. It seems to me that there is a great middle ground between the purely cultural training, on the one hand, and the training in the domestic and mechanic arts on the other hand, which ought not to be neglected. And yet I fear from all statistics that this great middle ground of learning is being lost largely from our educational system. The latest statistics I have seen show that the purely, or largely, culture studies, foreign languages, English, foreign history and a certain type of mathematics are holding their own. Domestic economy, so-called, agriculture and manual training are gaining ground rapidly. The fundamental natural sciences and the social sciences are on the decline.

I was asked to speak on the topic, "The Relation of Science and Mathematics to Business and Industry." I should like to add the words *and to Social Service.* I should like to add these words because it seems to me that social service is neglected in all our schemes of education which neglect the basic natural sciences and the social sciences. Neither an education for culture nor an industrial education places emphasis on service for others; on the contrary, it centers attention on self-interests. An education which places the emphasis on culture elements does indeed enable one to live a richer life and a life which reflects on his family and on those with whom he associates but it rarely leads to social service. A training in the domestic or the mechanic arts or in agriculture smacks of a trade and that is of itself a guarantee of a tendency to center life interests in achievements for personal advantage. And so I plead for the retention of the basic sciences, natural and social, as an integral part of an education for every American boy and girl. Statistics seem to indicate that mathematics still hold a reasonable place in our educational scheme.

But to proceed with my subject: It is a trite and commonplace observation to call attention to the fact that in these days of sharp competition, every industry and every large business must be operated upon a more-or-less scientific basis in order to survive. The highest paid employes, possibly, excepting for administration, are men and women trained in science. In all construction work and in the operative positions generally, the engineer, a man trained in mathematics and science finds his calling. It has been said that it is the function of the trained engineer to show his employer how to construct better and for less money and how to operate more advantageously and at less cost.

But engineers are trained in technical schools, and I take it that we are chiefly concerned in seeing how high school science and mathematics are related to industry, business, and, may I add social service. While the trained engineer serves humanity in the grander sphere, we of the common people must depend almost entirely upon the services of the common laborer. Would the average man be a better common laborer if he were versed in the fundamental principles of science and mathematics?

As I have watched the uneducated, but apprentised-trained, mechanic at his work, I have often noticed the close approximate adherence he makes to applying scientific principles. He practices his art and trade as he was taught, modified, perhaps, by the lessons taught by experience. Nevertheless, I can but believe that his progress would be greatly accelerated and his work materially improved if he had received, as a youth, a training in but the rudiments of science. I shall take time for a single illustration only.

Some years ago I was talking with the foreman of a plumbing gang working on a large contract. The conversation turned upon the point of lack of scientific training in science of the ordinary workman. The foreman had received a good training in science and had partly completed an engineering course when adverse circumstances forced him out of school and into life's work. He was a bright, intellectual young man. He told me that he had to teach almost every plumber who came on the job how to "wipe a joint." He said that the ordinary plumber does not know how to wipe a joint economically as to time, and material, or how to make it most durable and neat in appearance.

To "wipe a joint" is to unite two pieces of lead pipe, or a piece of lead pipe and a brass fixture often, by means of solder. The

joint must be strong, water-tight and should not be unsightly. With due consideration of these requirements, it should be made at the least cost for material and time.

The operation consists of two processes: First, the preparation of the joint, and second, the actual wiping of the joint. Time consumed in the proper preparation saves both time and material in wiping. One of the two ends of pipe to be joined must be somewhat flared, increased in size, by means of a turnpin, a tapering, pear-shaped piece of wood. This end is called the "socket." The other end of pipe to be joined is tapered down by means of a rasp till it enters the socket. All parts with which solder is to come in contact must be scraped clean and fluxed with tallow.

According to my informant, the proper method of preparing, let us say, a one-inch pipe for wiping is to use a rather long, slim turnpin for spreading the socket. This makes the opening in the socket a gently spreading one. The spigot, or "male" end, as the plumber calls it, should be rasped to a gentle slope corresponding to the slope of the socket. On a one-inch pipe, the surfaces thus brought in contact should be about one-half inch in length, and the sides should be nearly parallel. The solder, melted and heated to the right temperature, when poured into such a prepared joint completely joins the two pipes for a space of one-half inch in length. In such a joint there is little need of "wiping on" a ball of solder over the joint. My informant said that such joint will be durable and strong even though little or no solder were wiped over the joint. (Fig. 1.)

This is not the most usual method of making a wiped joint, however, according to my informant. A blunt turnpin is often used to open the socket. This turns the socket out with an abrupt flare. The spigot end is rasped off at a sharp angle to match the socket. There is but little surface of the two pipes in contact. To make the pipe sufficiently strong, a large egg-shaped ball of solder is laboriously wiped over the joint. Too often the wiping is done at too low a temperature, causing the solder to crystallize and become porous. As a consequence the joint is porous, or "sweats" as the plumber says. (Fig. 2.)

I have purposely chosen a rather technical application of science to the industries, and yet an illustration which is to be found in almost every home. Does it appeal to us that there is science involved in the wiping of a joint? Is it a case where the science taught in our high schools can be readily applied by

the ordinary plumber? Do we observe in our own homes whether the wiped joints sweat? Can we ever hope by a more effective teaching of science in our high schools to train young people to think scientifically in the performance of their daily task? Can we hope that the day will come when ordinary trade workmen will be trained in our high schools before they learn their trades? Till that time arrives, must we not expect to see most of the work, by even so-called skilled workmen, really done by rule of thumb? And until then, what proportion of us who employ such laborers will accept their work without inspection and without question so long as it is passable?

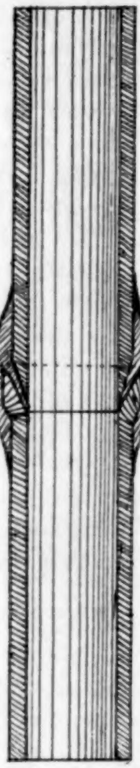

Fig 1.

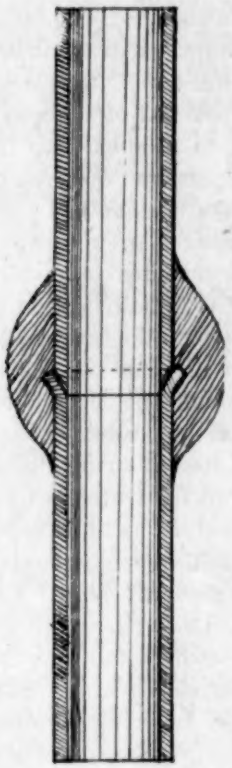

Fig. 2.

The thought I have tried to give expression to regarding the relation of science to industry and to business is this: So far as the high school is concerned, we must hope and expect to be of the greatest service in doing what we can to induce every high school student to include a fair amount of science in his course. Next, we must see to it that the science we teach is not mere

abstract principles, unrelated to the affairs of life, but it must be largely based upon applications of science as we meet life conditions. It is only when science is thus taught that it functions when needed.

How often have we all seen a man or woman who has had the ordinary training in high school science who fails to think out the problems of life involving science for himself or herself. I have a neighbor who is considered quite scholarly in most ways but who frequently astonishes me by misapplying what he believes to be his training in science. His duties are such that he must leave home in the morning and does not return till night. He has read, and he knows, that the proper firing of coal for the production of steam is to fire frequently and not too heavily at any one time. He knows that for steam production a moderately thick bed of coals frequently replenished with a rapidly burning coal produces the best results. He therefore reasoned that the same was the best method of firing his furnace. However, he soon complained to me that his young wife found caring for the furnace a great burden. I suggested that he secure a very hard, slow burning coal, which is always available, and which we always receive delivered in large blocks which must be broken in order to pass the furnace door. I suggested that he maintain a heavy bed of coals but seldom or never permit the draft to remain open and the check closed for any length of time. In short, since it was impossible for him to be at hand to feed the furnace as he would feed a steam boiler furnace, i. e., maintain a rapidly burning but light fire, to try maintaining a heavy, slow burning fire all the time. At first he could not believe that such a method could be followed; now he is just as certain that the plan I suggested is the only plan for him.

The inability to adapt the science which the high school graduate really knows is the monstrous failure of our high school science teaching. Some way or other we fail woefully in our science teaching to stimulate independent thinking on the part of our high school graduates when they come to the point where they must apply science to industry, business, or the art of domestic life. Until we overcome this failing, I am saddened to believe the value and worthwhileness of science instruction will be questioned by educators.

It would be as trite for me to dwell upon the necessity of mathematics in modern industry and business as it would be to dwell upon the necessity of science. All industry and business

survives only when quantitative values and relationships are appreciated and practised. I question severely whether the mathematics taught in our high schools aids materially in fixing the appreciation of the value of, and ability to apply, these quantitative relations of life. In his daily routine of life's work the business man soon becomes quite expert and almost automatic in handling the quantitative values and relation with which he has to deal. The mathematics he learned in the grades is often quite sufficient to meet his needs; the mathematics taught in the high school is rarely of use to the business man or the common industrial worker. What we as high school teachers should strive to do is *not* to see into how intricate and difficult mathematics we can lead our high school students to pursue but rather how thoroughly we can ground them in the fundamental processes which they can and must use in their common life experiences. The vital relation of mathematics to industrial and business life, so far as we, the high school teachers, are concerned, centers chiefly in the efficient use of arithmetic, not in the theory of surds and logarithms or in the solving of originals in spherical geometry.

I have mentioned the fact that the business man forms the habit of handling the routine quantitative, mathematical relations of his daily business with accuracy and expedition. But he does not show ability to adapt his mathematical ability to new situations. Let him stray from the unusual routine and he manifests little mathematical ability. Nor, in my opinion, will the hasty survey of the more advanced algebra and geometry now taught in the high school produce a generation of business men and industrial workers more capable of orienting themselves and handling new mathematical situations efficiently.

Allow me to illustrate from recent experience. Some three weeks ago I sat on the canvassing board of our recent election. It was our duty to canvass the vote for thirty-four precincts, nearly 10,000 votes. The returns from many precincts were more or less in doubt. We were obliged to subpoena the election boards from two precincts and have them revise their tally sheets and reports. In the case of one of these precincts seven out of eight totals on questions of public policy were found to be incorrect.

The men on this particular election board were good business men, the mayor, a city councilman, a real estate man, a shoe dealer, an U. S. railway postal mail clerk, and the clerk in

a state charitable institution. We can hardly attribute the errors to indifference. There was plenty of evidence of lack of method of procedure. But I believe that the inability to adapt themselves and their mathematical learning to a new situation was the chief difficulty. Surely no advanced mathematical concepts were required of these men in order that they might fulfill a social and community duty.

My conclusion regarding the relation of science and mathematics to industry and business, so far as it is a high school problem, is briefly this: We are not today teaching, in our high schools, either science or mathematics, as a rule, in such a manner as to make a strong appeal to the student, nor in such a way that they function readily in later life. We are too ambitious to reveal to the student those subtle wonders of science and the finer revelations of mathematics which most lately came to us. We neglect the fact that the high school course completes the student career of the large majority of the young people who are fortunate enough to enjoy even that privilege. We are placing the emphasis too largely upon the grander revelations which have most recently come into our own consciousness and which, undoubtedly, will be of interest and value to the negligible few who will proceed through the college, university or technical school. When we as high school teachers learn to appreciate the fact that the public high school is the *finishing school* for a small, but fortunate minority of the men of industry and business of the next generation, we shall lower our rear sights and aim at teaching science and mathematics which will be most useful in those callings, and we shall make a mighty effort so to teach what we do attempt in a manner that it will function in the explanation of the common experiences of life.

THE NOBLE COCKROACH.

If the test of nobility is antiquity of family, then the cockroach that hides behind the kitchen sink is the true aristocrat. He does not date back merely to the three brothers that came over in 1640 or to William the Conqueror. Wherever there have been great epoch-making movements of people he has been with them heart and soul, without possessing any particular religious convictions or political ambitions. It is not so much that he approves of their motives as that he likes what they have to eat. Since ever a ship turned a foamy furrow in the sea he has been a passenger, not a paying one certainly, but still a passenger. But man himself is but a creature of the last twenty minutes or so compared with the cockroach, for, from its crevice by the kitchen sink, it can point its antennae to the coal in the hod and say: "When that was being made my family was already well-established.—[Sutherland.

A STUDY OF THE FACTORS IN THE EFFICIENCY OF BOYS' AND GIRLS' CLUBS.

By W. W. Charters and James H. Greene,

Pittsburgh, Pa.

During the club seasons of 1917 and 1918 statistical studies of boys' and girls' clubs in Illinois were made for the purpose of seeing what effect certain factors had upon the actual efficiency of the clubs.

Club efficiency was determined by the percentage of the net enrollment reported by club leaders, as completing the projects undertaken. By net enrollment is meant the gross enrollment reported, minus those dropping the work because of removal, sickness, and other "unavoidable" causes. (This word in quotations was indefinite but constituted only a very small fraction of the returns with an enrollment of 1,952.)

Returns were received from 108 clubs in 1917 and from 102 clubs in 1918, with a total enrollment of 1,631. That these were a random sampling of the clubs of the state was ascertained in 1917 from data obtained from county superintendents and farm advisors concerning clubs which did not report. These data were to the effect that of the clubs not reporting 9 clubs enrolling 181 had organized but had not met, 18 with an enrollment of 931 had continued for a time and stopped and 19 with an enrollment of 1,117 had been carried to successful completion. It was, therefore, thought unnecessary to check the sampling of 1918.

In both 1917 and in 1918 the clubs were arranged in the order of efficiency from 100 per cent down. For purposes of study they were divided into four groups, approximating the four-fourths of the lists with modifications necessary to avoid separating clubs of equal efficiency into different groups. Table I displays the grouping.

Table I.

		I	II	III	IV
1917	Per cent of Efficiency	100	99–89	88–65	64–0
	Clubs and ranks	1–41	42–56	57–81	82–108
1918	Per cent of Efficiency	100	95–76	75–54	50–0
	Clubs and ranks	1–25	26–50	51–76	77–102

This table reads so as to show that in 1917 clubs 1-41 included in Group I had an efficiency of 100 per cent, clubs 42-56 had a range of efficiency from 99-89 per cent and so on. It is interesting to note the relatively higher efficiency of the clubs in 1918.

These groups having been thus determined, several studies were made to determine the influence, if any, of some twelve factors supposed to be of value in club work. These will be presented in serial order.

The Local Leader.—In 1917 a study was made of the occupations of the local leaders. Reports of occupation were received from 82 of the 108 clubs and it was found that 58 were teachers, 6 were farmers, 3 were ministers, 6 were housewives, and 11 were of miscellaneous occupations. The members of all except the teachers were too small for the drawing of any conclusions. In the case of the teachers, it was discovered that while 71 per cent of the leaders reporting were teachers, 79 per cent of the leaders in Group I were teachers, 75 in Group II, 73 in Group IV and 55 in Group III. This may be interpreted as showing that the fact that the leader is a teacher is no indication of the particular group in which the club will be found. They were highest in Group I and lowest in Group III but almost as high in Group IV as in Group I. The cause of this neutrality of effect is probably due to the fact that superior leadership is counterbalanced by absence during the summer. The six farmers were distributed 50, 17, 17, 17 in the four groups, and the 6 housewives 33, 17, 17, 33; but six cases were too few to be of value.

Advisory Committee.—In 1917, the clubs of Illinois were directed to have advisory committees of adult farmers. From 67 clubs reporting in that year it was found that of the 100 per cent clubs (Group I), 68 per cent had no advisers, 21 per cent had good advisers and 11 per cent had unsuccessful advisers. This means that 89 per cent of the best clubs had either no advisers, or advisers who did not advise. For groups II, III, and IV, corresponding totals were 50, 50, and 73. It would seem that so far as these clubs were concerned an advisory committee was not essential to success.

Club Officers.—In 1917, it was found that of the 81 per cent of clubs reporting the percentage of clubs having officers and a formal organization in each group from I to IV was 100, 86, 84, and 73. This shows an interesting fall, the less efficient the club, the less likely to have officers.

Meetings.—In 1917, in 51 per cent reporting it was found that the average number of formal meetings per club ranged in Groups I to IV as follows: 7.6, 14.4, 8.6, and 4.9. In 1918, in 85 per cent reporting the range is as follows: 10.2, 8.6, 7.8, and 7. There would, therefore, appear to be some correlation

between efficiency and the number of meetings in 1918, this is reinforced in part in 1917 where the poorest group has the smallest number of meetings.

Paid Club Leaders.—In 1917, four clubs had paid club leaders. Of these one was found to be in Group II and 3 in Group IV. This number was not large enough to warrant drawing the superficial conclusion that paid leaders were not as successful as volunteers. Particularly was this the case because of the fact that the paid leaders were placed in charge of propositions which were considered to be too difficult for volunteers. All of the clubs had over 40 members and therefore were not so likely to bring as large a percentage through to completion of their projects.

In 1918, there were no paid local leaders with the exception of teachers in the Rockford city schools who were paid a small salary for summer work. A large per cent of the local leaders of the clubs included in the 1918 report were teachers and hence for the period of the school term might be considered in a sense as paid local leaders. Inasmuch as the clubs with teachers as leaders are distributed quite uniformly, they are not singled out for discussion. Of the *five* Rockford clubs reporting, however, *two* are in the first group of 100 per cent clubs, and *three* are in the second group. The data is too meager from which to draw conclusions but it would seem, other things being equal, that the payment of leaders to secure all-the-year round service is undoubtedly profitable. Observation leads to the conclusion, however, that payment in and of itself does not necessarily secure the type of service desired.

The size of the most efficient club.—The determination of the maximum and minimum size for best work is naturally of great practical interest.

In 1917, the clubs ranged from two clubs of one member (net enrollment) to one of 160. The following table indicates some of the salient facts concerning the range of clubs in each group:

TABLE II.

Summary of Measures of Relations Between Size of Club and Efficiency.

Measure—size of clubs	I	II	III	IV	To'l
No. of clubs in group	41	15	25	27	108
Upper extreme	1	10	4	1	1
Lower extreme	48	109	46	160	160
Range	1–48	10–109	4–46	1–160	1–160
Twenty-five percentile (approx.)	5	13	7	8	7
Median	8	17	14	13	11
Seventy-five percentile (approx.)	13	24	18	25	10
Middle fifty per cent (approx.)	5–12	12–24	7–18	8–25	7–19

This table should be read as follows: The upper extreme or smallest club in Group I contained one club member and the lower extreme or largest club in the same group contained 48. The range in size, therefore, was from 1 to 48. The twenty-five percentile, or club which was one-fourth of the number of clubs proceeding from smallest to largest contained 5 members. The median or middlemost club of the series of clubs contained 8 members. The seventy-five percentile or club three-fourths of the way down the series contained 13 members. The middle 50 per cent of the clubs ranged from 5 to 13 in membership. The data in the succeeding columns are read in the same way.

In 1918, the distribution of the same facts were as shown in Table III which should be had as Table II.

TABLE III.

Summary of Relations Between Size of Clubs and Efficiency in 1918.

Groups	I	II	III	IV
Upper extreme	3	6	5	4
Lower extreme	36	48	68	87
Range	3–36	6–48	5–68	4–87
25 Percentile	5	10	7	8
Median	10	13	11	11
75 Percentile	15	18	20	14
Middle 50 per cent	5–15	10–18	7–20	8–14

A further study shows that in 1917, 31 of the 41 clubs making 100 per cent had a membership of less than 12, and in 1918, of the 25 clubs having the maximum possible efficiency, 19 were less than 14. On the other hand in 1917, clubs with memberships of 103, 109, 120, and 160 had efficiencies of 99, 95, 64, and 57 respectively, and in 1918, clubs of over 30 members, viz., 32, 36, 39, 42, 43, 47, 48, 68, and 87, had efficiencies of 47, 100, 21, 50, 70, 81, 85, 72, and 44, respectively.

While these figures prove nothing conclusively, they indicate that so far as mortality is concerned, the small club ranging from 7-15 is preferable and that very large clubs are not so satisfactory. But it is a question whether so far as the good done to a community is concerned, a club with a membership of 100 which has an efficiency of 50 per cent and brings 50 members through to the completion of the project, is not better than one of 10 with an efficiency of 100 per cent but which brings only 10 through. This, however, can be obviated, in part, by breaking a large club into several small ones and thus obtain a lower mortality.

Making Reports.—In Illinois it is "required" that members shall make written reports to the central office at Urbana. It

is, therefore, possible to see if making of reports has any bearing upon efficiency.

In 1917, in returns from all but five of the clubs it was found that 76 per cent of the members in Group I (100 per cent clubs) 59 per cent in Group II, 61 per cent in Group III, and 38 per cent in Group IV sent in reports of their projects. In 1918, so many clubs failed to report this item that no trustworthy figures could be obtained. It is significant that in 1917 the efficiency of the clubs and the percentage of those reporting had a very high correlation.

Making Exhibits.—A similar study was made of the relation between efficiency and the making of exhibits which was persistently recommended in the club literature. In 1917, it was found that from 100 clubs reporting, out of a total of 108, the percentage of members exhibiting ranged from Group I to Group IV as follows: 37, 32, 32, and 21. In 1918, the range from Groups I to IV were 59, 52, 39, and 33. In both cases it appears quite evident that the stimulus that comes from the expectation of making exhibits and in many cases of winning substantial prizes at the shows is quite substantial.

Age Distribution of Clubs.—Membership in clubs is limited to those between the ages of 10 and 18, although some a year or two older or younger sometimes were admitted. There is much discussion among club leaders as to the range of ages of club members who do the best work. This table is an attempt to answer this question. The age given is the age at the last birthday. For this reason all calculations are made for years *only*. *Ten* years for example include 10 years and all months up to and including 10 years and 11 months. A range in years from 10 to 14 inclusive is considered as 5 years.

There is little or no relation between the ages of club members and the efficiency of the club in the several groups in either 1917 or 1918. In 1917 the medians of the median ages of clubs were 13 in Group I and 12 in each of the others. In 1918 they were 12 in each of the four groups. The extremes of the club medians were 10 years and 16 years in 1917 and 10 years and 14 years in 1918.

Range of Ages.—The opinion has been frequently expressed that the more nearly the members are of the same age the greater efficiency. This is not borne out by the data of 1917 or 1918. In 1917, the medians range, counting a club with children ranging from 12 to 15 years as a range of 4 years, were 5, 6, 6, and 6

years respectively for Groups I to IV. In 1918, the median ranges for each group from I to IV were 3, 4, 5, and 5. The extremes of range for the four groups were from 2 to 8, 1 to 7, 1 to 10, and 3-11. In 1917 there seemed to be no perceptible advantage in having a narrower range of age in the clubs, but in 1918 there seems to be a tendency for the clubs with membership closer together to achieve higher efficiency although the extremes between the smallest and lowest ranges in individual clubs is about the same in each group.

Efficiency by Individual Ages.—It was found in 1917 that there was no great difference in the probability of children of any age achieving greater efficiency where enough cases were avilable to work out any conclusion. This is shown in Table IV which shows, for instance, that of the two pupils 7 years of age enrolled, none completed a project and 2 did not. It will be observed that there is no steady rise or fall of any pronounced sort either toward the lower or the upper ends of the table.

TABLE IV.

Numbers and per cents of Members of Each Age Completing and Not Completing Project.

Age	Total	Completed	Per Cent	Did Not Complete	Per Cent
7	2	0	0	2	100
8	5	3	60	2	40
9	16	9	56	7	44
10	154	128	83	26	17
11	207	170	82	37	18
12	288	234	81	54	19
13	246	190	77	56	23
14	214	167	78	47	22
15	128	105	82	23	18
16	81	66	81	15	19
17	43	37	86	6	14
18	18	16	89	2	11
19	2	2	100	0	0
20	2	2	100	0	0

It was found in 1917 that the mixed clubs, those in which the members worked on different lines of projects, were not so likely

TABLE V.

Comparative Efficiency of Four Leading Projects and Normal.

	Normal	Garden	Corn	Canning	Mixed
	%	% Plus or Minus	% Plus or Minus	% Plus or Minus	% Plus or Minus
I	38	41 Plus	50 Plus	40 Plus	30 Minus
II	14	22 Plus	18 Plus	6 Minus	13 Minus
III	23	15 Minus	18 Minus	33 Plus	33 Plus
IV	25	22 Minus	12 Minus	22 Minus	23 Minus

to be efficient as were those in which the club members all worked on projects of one sort as garden, canning or corn. The same result is found in the 1918 reports. The degree of correlation is shown for 1917 in Table V.

Conclusion.—The foregoing observations are chiefly suggestive and may lead to some modification of practice. The personality of the leader probably is of more importance than any other single item and that has not been measured in this investigation. Meagre as are the results of the study it is of importance as an example of the type of investigation which must be made to verify or refute the wisdom of many of the rules and principles followed by club organizers.

HELP THE STUDENT SELECT.

By J. E. Running,

High School, Dickinson, N. D.

How do high school students decide what electives to choose? To what extent are they guided by the advice of others? How many select a particular subject because they are particularly interested in the subject matter that they expect it to treat of? How many select subjects because they expect them to be easy?

I tried to get an answer to these questions from the students in my own classes in the following manner: The first day of school I handed to each student in my classes a card on one side of which I asked them to write their names and on the other side the reason for taking that subject. Our courses of study are so flexible that every one of my subjects—physics, chemistry, and general science—can be looked upon as an elective. General science is given in the ninth grade, chemistry in the eleventh, and physics in the twelfth. Following are the tabulated results:

	General Science	Chemistry	Physics	Total
Advised by parents	11	4	0	15
Advised by brother or sister	2	3	0	5
Advised by other student	8	2	2	12
Advised by teacher	3	1	0	4
Advised by doctor	1	1	0	2
Interested in science	8	9	8	25
Interested in laboratory work	0	7	6	13
Considered valuable	2	3	6	11
To prepare for college	0	3	0	3
To earn a credit	0	2	0	2
Told subject was easy	0	1	0	1

SUMMARY.

					Pct.
Advised by others	25	11	2	38	41
Per cent	71	30	9		
Interested in subject itself	10	22	20	52	56
Per cent	29	61	91		
No special purpose	0	3	0	3	3
Total	35	36	22	93	

Note that the per centage taking the subject on the advice of others decreases from 71 in general science (freshmen) to 30 in chemistry (junior) and 9 in physics (senior); and that the percentage taking the subject on their own initiative increases from 29 in general science to 61 in chemistry and 91 in physics. Note also that less than 4 per cent "drifted" into these classes.

If any conclusions at all can be draw from the statements of so small a number it shows that there is less indifference among high school students than they are generally given credit for. It also shows that students develop independence and are finding their own interests while progressing through high school. If this be true, high school students should be given more instruction as to just what the different subjects treat of so that they can make their selections more intelligently. Since the above figures show that students are finding their interests while in high school, more should be done to show them the things attracting and the preparation required for success in the different vocations, so that they may at that time, if possible, decide upon their life work and have more time to prepare themselves for the greatest of efficiency in their own selected field.

SHOULD GUARD AGAINST FOOT-AND-MOUTH DISEASE.

"The department is responsible for the protection of the live-stock industry against the introduction of nearly a score of serious foreign live-stock diseases," declares the Secretary of Agriculture in his annual report. "One of the most infectious and dangerous of these," he adds, "is foot-and-mouth disease, which exists nowhere in the United States at the present time, but is a constant menace because of the facility with which it may be carried by animals, hides, and various live-stock products.

"The importance of prompt action in eliminating any centers of infection whenever they develop emphasizes the necessity of providing an adequate 'insurance' fund, available for immediate use. Such a fund, to be used only in case of actual outbreaks, has been carried in the Agricultural Appropriation Act for several years. The appropriation was reduced by $950,000 at the last session of Congress, leaving an amount which is entirely inadequate to cope with serious outbreaks.

"While, through good fortune, no outbreak has thus far occurred during the current fiscal year, it would certainly be the part of wisdom to make liberal provision for dealing with this dangerous disease whenever it appears, and the department, therefore, has recommended in its estimates for the fiscal year, 1921, that the appropriation be restored to its former figure."

FROM THE COMPLEX TO THE SIMPLE.

By Jos. A. Nyberg,

Hyde Park High School, Chicago.

In mathematics we progress from the days when we first counted on our fingers till we advance to and through calculus into the more complicated machinery. Our steps take us from the simple ideas to complex ones. This is the natural order, and no subject adheres to it more closely than mathematics. But we have made some mistakes by confusing *lengthy* processes with *complex* ones. A California redwood requires more time to mature than a violet or arbutus but the process is not therefore more complex.

Consider, for example, the subject of factoring and the order in which we are led from the simple problems to the more complicated. We begin with factoring $3x+3y$, learning in the first step how to detect a monomial factor and advancing to $6x^4y+9x^3y^2+27x^2y^5$. Then we begin a new type such as $x^2+7x+12$ and proceed through a list of problems, in each of which the coefficient of the square is unity, until we reach a quantity like $x^2-84x+243$. Again we start a type $x^2+4x-12$ which, to judge from the books, is more complicated than any of the preceding because the constant term is -12 instead of $+12$. And at the end of each of these lists we have similar quantities from which a monomial factor must first be extracted according to the printed "hints." Next we begin with $2x^2+7x+5$, the numbers 2 and 5 being chosen because they are prime numbers; and then lead up to $12x^2+41x+24$, since 12 and 24 have various factors, the problems afterwards being complicated by the introduction of minus signs and monomial factors. Somewhere in this arrangement we consider perfect square trinomials, and the differences of two squares, proceeding in each case from x^2+2x+1 to $4x^2+12xy^2+9y^4$ or from x^2-y^2 to $9x^4-16y^2$ and always ending each list with some monomial factors.

Such an arrangement we call pedagogically sound because it leads from the simple to the complex. The following paragraphs present a different order which may appear to proceed from the complex to the simple but which is nevertheless sound pedagogically.

The class, let us assume, has reached the stage where it can perform mentally such multiplications as $(6m^2-7n)$ $(2m^2+3n)$ but has had no work at all in any kind of factoring. Some day, apparently as if by accident, I very suddenly interrupt the pupil

reciting such a product and, pretending that a burst of inspiration has unexpectedly come upon me, I ask, "I wonder if anyone can tell me what quantities I multiplied together if I tell what the product is?" On the blackboard I write $12x^2-7xy-10y^2 = (\quad)(\quad)$. The $12x^2$ I must have obtained by multiplying $6x$ by $2x$, or $4x$ by $3x$, or $12x$ by x, the $-10y^2$ by multiplying $-5y$ by $2y$ or $5y$ by $-2y$, etc. We experiment to see which of these will produce $-7xy$ for a middle term. No rules are given, not even for signs as the class must surely know how to multiply any two terms. Then the class is sent to the blackboard to work problems like the one above, but not a bit easier. No coefficient is unity; every quantity contains two letters. A quantity like $x^2+7x+12$ will not arise till several days later, and x^2+6x+9 arouses no comment even though every pupil writes it as $(x+3)(x+3)$; and even $9x^2-4y^2$ causes no stir as the pupil tries for such combinations as will make the middle term $0xy$. Zero, I have frequently said, is just as good and respectable a citizen of the number family as any other citizen; and since we have never had occasion to divide by it, we assume it obeys the same laws as other citizens. Thus the work is begun not with the simplest problem of its type but with a more general type.[1]

Then some day when the class is at the blackboard I read off $32x^2+8x-12$ and the results will be either $(8x-4)(4x+3)$ or $(2x-1)(16x+12)$, followed by an argument as to which is right. We verify the result by multiplication and also by the substitution of some number, say $x = 2$. In verifying it, some of the pupils have obtained $132 = 12.11$, others $132=3.44$ concluding that both are correct. I then ask, "How, in arithmetic, can we show that $12.11 = 3.44$ without multiplying the factors?" We are thus led to consider prime factors and learn that $8x-4$ and $16x+12$ can be factored further. After seeing that the monomial factor is visible to all keen pilots in the original polynomial as well as in one of its factors, our next discussion hinges on the question "Which is the better method: to dislodge the monomial factor at the beginning of the process or at the end?" We conclude that it is best done at the beginning, for then our work will be more rapid because $8x^2$ has fewer factors than $32x^2$.

[1]To add a few words on the subject of factoring, I might say that x^2-y^2 is not to be regarded as the difference of two squares but as the sum of x^2 and $-y^2$, and this attitude must have been adopted and used previous to factoring. Similarly, x^3-y^3 is not the difference of two cubes but the sum of x^3 and $-y^3$. The memorized rules for factoring x^3+y^3 and x^3-y^3 will then read: one factor is a binomial and is the sum of the two cube roots; the other factor is a trinomial, two of whose terms are the squares of the cube roots and the other term is the negative product of the two cube roots. However, it is better to postpone the factoring of the sum of two perfect cubes until such a quantity is reached in the study of the simplification of fractions. At that point the pupil is more ready to appreciate the fact that if we know one of the factors of a polynomial the other factor may be found by division.

After this discussion the next problem assigned is $18x^4y+15x^3y^2-12x^2y^3$, not $2x^2+14x+24$.

After using this method of proceeding from the complex to the simple for several years, I decided to experiment with other subjects to see if it was always necessary to begin with the apparently simple and lead up to the apparently complex, also aiming to uncover some general theory that would explain where and why the method works.

Consider a subject in which the method will not work: quadratic equations. The following equation are typical of our steps in the subject: $7x^2 = 63$, $3x^2 = 25$, $x^2+6x+9 = 25$, $x^2+4x = 5$, $x^2+10x = -21$, $x^2+6x+7 = 0$, $2x^2+8x-9 = 0$, $4x^2-20x+19 = 0$, etc. Here, obviously, we can not reverse the order and begin with the last equation. The reason is equally obvious. To solve $ax^2+bx+c = 0$ the pupil must know how to solve $x^2+px+q = 0$ and to do this he must know $x^2+2kx+k^2 = m^2$. Each step in the solution of $ax^2+bx+c = 0$ involves a reduction of the equation to a simpler standard form. On the other hand, factoring $8x^4+2x^2y^3-15y^6$ does not involve reducing this to a quantity the coefficient of whose leading term is unity.

We need proceed through the simple problems A, B, C, D, to the complex problem E only when the individual steps A, B, C, D arise in the solution of E; i. e., when the problem consists in reducing E to D, D to C, C to B, etc.

For example, when beginning fractional equations we have the steps: A, $2x/3 = 8$ in which we learn the multiplication axiom. Then B, $x/5+x/6 = 11$ in which we learn to select a L. C. M. Next C, $x/7+x/14 = 9$ wherein the L. C. M. is not the product of the denominators. Then step D, $3x/8+2x/5 = 1/10$ etc. These are followed a semester later by $(5x+12)/6-4(2x+7)/11 = -1/3$ which in turn leads to $6/x+5/2x = 1/6$ and $(x+6)/(x-3) = 1/8+(3x-4)/5$. Does the solution of any of these equations consist in reducing it to one of the type immediately preceding? Since it does not, we may begin anywhere in this list just as well as at the first, The word L. C. M. need not be used at all. Until and unless the pupil reaches a problem like

$$\frac{x+6}{4x-14}-\frac{2x+3}{9x+15}=\frac{6x+1}{6x^2-11x-35}$$

he need not worry about the *least* common multiple very much. The multiplier is merely a broom which properly applied to the fractions is guaranteed to sweep away any and all denominators.

Its only important characteristic is that it must be *divisible by* every denominator. To avoid using a carpet broom when a whisk broom will do the work, the pupil must first observe whether the denominators are different or involve repetitions. Then, it is just as easy to find a quantity divisible by $2x$ and 5, or by $(x-3)$ and 8 as to find one for 7 and 14. And at the time when a pupil is ready to work with fractional equations it is no more difficult for him to multiply binomial quantities than monomial terms.

The objection will be raised that there are other things to be taken into consideration; for example, even though a pupil may begin at the step E, will he be able to work the prose problems whose equations are of the type E without first working prose problems whose equations are of the kind in the steps A, B, C, D? To this question we can answer that if we include in our drill problems only such quantities or equations as may arise in prose problems we may as well throw away half of our algebra, as the exercises for drill are always much more complex than anything which arises in the prose problems. Ability to solve prose problems comes only gradually and their difficulty lies not in the algebra but in the lack of imagination or visualizing ability of the pupil. The pupil would have less trouble with them if he could see the automobile starting two hours later and then overtaking the train, could draw a picture of the Washington Monument, had made a few thousand dollar investments or had mixed some brands of tea. In fact, the more practical we make our problems the more difficult do they become. Hence this paper applies to the drill problems mostly. Mostly, but not entirely; perhaps some of our prose problems also need revision. As an illustration of this, let us consider "age" problems and some time, rate, and distance problems.

The ages of John and Henry we will say are x and $2x$ respectively; then an equation is formed comparing their ages five years hence. In other words, only two years, 1921 (now) and 1926 (5 years hence), are involved in the problem. Is the problem any more difficult if we compare Henry's age in 1931 with John's age in 1926, or Henry's in 1927 with John's in 1908? Is any advantage gained by thus complicating (?) the problem? There are several. One of the things which the pupil is supposed to learn from age problems is the translation into algebra of such words as "five years hence," "ten years ago," etc. If both of these terms occur in the same problem, the pupil's attention

is called to the difference between the plus and minus sign more sharply than if the idea "hence" occurs in one problem and the "ago" in another. Another advantage is seen when we write out the equation for the problem: A father is nine times as old as his son; nine years hence he will be three times as old. Here the equation is $9x+9 = 3(x+9)$. Note the prominence of the number 9. There are in this problem really two different nines, one arising from "nine times as old" and the other from "nine years hence." The pupil may easily confuse the two ideas because he is not called upon to distinguish between them[2]. The trouble is that, without introducing fractions, we can make up few "age" problems which do not mix and repeat a number. But this trouble does not arise when using both "ago" and "hence" in the same problem. Neither would it arise if we did not feel compelled to make the problem simple by saying always that one age is a multiple of the other, but said that one age exceeded a certain multiple of the other by some amount.

When the subject of rate problems is to be considered and the pupil has become acquainted with the relations between d, r and t, the problems presented to him are variously graded. And it seems that a problem which can be printed in two lines must be simpler than one requiring three or four lines. But whether the men travel in the same or in opposite directions, toward or from each other, or whether the unknown is d, r or t, it is useless to try to grade the problems into types so that the solution of one involves a reduction to a previous type. Hence, as in factoring, we may as well begin with a general type instead of considering each type separately. And our grading will be based not on the number of lines required to print the problem but on the extent to which the problem calls on the pupil's imagination or visualizing ability. Thus, it is easy to draw a picture of the distances involved in the following problem[3]: A and B travel toward each other from points 200 miles apart, A starting 3 hours before B. A's rate per hour is 6 miles more than twice B's. When B has

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[2]The problem may be compared to that of asking for the square of a^2. From the pupil's answer we can not tell whether he knows the laws of exponents or not.

[3]Most teachers, I think, believe that the above problem must be approached gradually through a list in which A's rate must at first be the same as B's, then double B's, then six more than B's or six less, etc.; that A's time must first equal B's, then one hour more, then two hours less, etc.; that their distances traveled must first be the same, then A's 60 miles more than B's etc. That is one of the mistakes we have been making. Such approaches may be greatly minimized if the pupil, not only during the first month but occasionally thereafter, has drill in such exercises as "What quantity is 6 more than twice another?" or "Write a quantity which exceeds b by the square of a." Such translations ought to be reviewed whenever the pupil for the first time meets an exponent, a fraction, parenthesis, radical, or any other mathematical symbol.

been on the road 4 hours he learns that A is 68 miles away. Find the rate of each. This problem would have been increased, not lessened, in difficulty if it had said that B meets A in 4 hours. The pupil has a harder time seeing that their distance apart is zero miles than 68 miles. The *zero* ought to arise later just as it does for the middle term when factoring a polynomial.

Having seen how some of the prose problems may need revision let me point out a few places where we need to change the drill work.

The axiom of division is usually illustrated by an equation like $3x = 12$. The equation $3x = 14$ would be better especially if the pupil is required to answer 4 2-3 instead of 14-3 as only then can we be sure that he is actually dividing and not guessing. The equation $1.4x = 3.738$ and others like it ought not to come at the end of the list but at the beginning.

The axiom of multiplication is usually begun with an equation like $x/3 = 5$. The pupil may answer $x = 15$ without having done any multiplication as he is merely recalling having seen $15/3 = 5$. If we begin with $2x/3 = 12$ the pupil's impression is merely "multiply by one of the numbers and divide by the other to get the answer" and the next day he is just as likely to multiply by 2 and divide by 3. It is better to begin with $2x/3-5/7 = 13$, writing the next step as $21(2x/3-5/7) = 21.13$. This implies that the multiplication axiom will not be used until after the introduction of parentheses.

The drill in long division should not begin with dividing $x^2+7x+12$ by $x+4$. Nothing is gained and much is lost by having the remainder zero, or the problem so simple that the answer can be guessed. Algebra becomes formal and mechanical when the problems do not require thinking or attention. Begin with $(10x^2-7xy+8y^2)\div(2x-3y)$ or $(8a^3-2a^2-27a+20)\div(2a-3)$.

When drilling on the multiplication of binomials mentally, the type $(2a-3b)(2a+3b)$ should not be considered as distinct from any other binomials, and the type $(2a+3b)^2$ should be considered *last* of all, not first.

In an earlier paper[4] I pointed out why the simplification of $6(3x-2)(5x+4)-2(x+5)(3x-4)$ should precede $(x+2)(x+3)-(x+4)(x+5)$

When quadratics are solved by factoring $18x^2-9x-20 = 0$ ought to precede $x^2-3x+10 = 0$.

The simplification of fractions ordinarily begins with 6/4

[4]School Science and Mathematics, May, 1920, page 436.

and $2a/6$ and leads up to a^2/ab, $42x^2/14xy$, $2a/(a^2+ab)$, $(x^2-6x+8)/(x^2+x-6)$, etc. Much hard work is always necessary to convince the pupil that he may not cancel the xs in $(x^2-1)/(xy+y)$ but may in x^2/xy. This difficulty can be lessened by beginning with $(15x^2-x-2)/(3x^2+13x+4)$ and using in the list of exercises some quantities which can not be factored at all (and hence can be reduced only by long division) and some quanti'ies in which no factors are alike so that again no cancellation is possible. After the pupil has seen that cancellation is not always possible then $a^2/(ab+a^2)$ is considered, and a^2/ab last of all.

It may well be that I have been carried away by my own enthusiasm; that, having used a method successfully in factoring or in fractional equations, I have stretched the method too far, and forced it to work where it was clumsy. But to those who believe in trying a method for its possible merits, I suggest the above plans.

AN EXPERIMENT IN SOCIAL HYGIENE AT CARLETON COLLEGE

BY GEORGE W. HUNTER,

Knox College, Galesburg, Ill.

Carleton College at Northfield, Minnesota, is one of the few so-called small colleges in the country doing aggressive work in social hygiene at the present time. The experiment here described was made possible during the year 1919-1920 because of the previous work done in physiology and sex hygiene by Dr. Neil S. Dungay, who has built up a splendid department of biology in the college. The department does work along four distinct lines: Zoology, botany, general biology and public health. It was in the latter work that I had the most interest. Coming as I did fresh from a year of war work, the need for social hygiene loomed strong. Two courses were established in the college for advanced pupils, one social hygiene and one for the teaching of sex hygiene. A third course, called "The Human Body"—a three hour course—was required of all Freshmen. The course, after a preliminary study of a few forms of plant and animal life as a background, took up the physiology and hygiene of the human body. It met a practical need of the students, many of whom were thrown, for the first time, on their own resources. Prior to my coming to Carleton, Dr. Dungay had devoted part of the time toward the close of the course to a specific treatment of sex hygiene. I took two out of three

sections of this course, in which there were about three hundred twenty-five students. It seemed to me that the course could be strengthened with the addition of some visual work, and so I arranged for the giving of two movies, "How Life Begins" and "The End of the Road." These movies were shown early in the spring at a time somewhat before the completion of the sex work, so that the correlation between the sex teaching in the classroom and the movies was not as great as it might have been. "The End of the Road" was given before any definite sex work was done with the classes. Attendance was required of the entire class and when the movie was shown, it was introduced with a short talk, telling of my own experience with it in the camps during the war, a little of the history of its composition by Miss Catherine B. Davis, and brief reference was made to the work of the Public Health Service and the American Social Hygiene Association. The movie was open not only to the Freshmen, but to all members of the college, both men and women.

The attitude of the audience was attentive, interested and respectful. There was no "horse play," no laughing; the entire audience seemed impressed with the picture and as I stood partly hidden from the crowd of young people as they passed out, I heard many comments which showed that the picture had made a deep impression.

It was my custom to give a brief test at the beginning of practically every lecture or recitation period at which the Freshmen classes met. Four days after the movie was given, the classes met at their accustomed times and were given a five minute test, at which the following questions were asked: 1. "How much of the material seen in 'The End of the Road' was new to you?" 2. "What was your general impression of the movie?" The answers of one hundred thirty men in my two sections are analyzed and their reactions are classified in the pages which follow. Forty-two women in a mixed section also answered the questions. It is hoped to classify their answers, together with about one hundred ten more in Dr. Dungay's women's class, in a paper which will appear later. It was noticed that the boys and girls reacted very differently to the movie, as we would expect. The boys gave much more detailed answers, seemed to be better informed on the fundamentals, were less vague and more specific in criticisms of what they had seen. The emotions of the girls were evidently touched much more than were those of the boys.

With reference to information gained, only five out of the one hundred thirty boys, stated that there were many things told by the movie that they did not know before. Fifty-six said that part of the material was new and in analyzing the answers, it appears to be specific effects of syphilis or gonorrhea. Twenty-one, most of whom had had army experience, said that none of the material was new to them, while forty-eight did not specify, but showed by their answers that they had much, but not all of the knowledge. Of the forty-three girls whose answers were tabulated, ten admitted that most of the material was new to them; nineteen said that it was partially new material, eleven said that there was nothing new told by the movie, while three did not specify.

Both men and women were unanimous in saying that the movie was good and that it ought to be given to all college Freshmen. One boy qualified his answer by saying that it was not good for mixed classes. Several others—boys—mentioned that they had seen movies which were more direct and to them more appealing, while in the army and navy, but only one thought that the others seen were better for college work. Three of the girls qualified their answers by saying that the movie was repulsive or unpleasant, but "supposed young people ought to see it."

The men's answers appear to fall into two general groups, depending upon the type of mind and in general the type of men. This is very noticeable in comparing answers of men whom I knew personally. I had a son in the Freshman class and was, therefore, able to know much more intimately a large number of his classmates than would have otherwise been possible. It is noticeable that the finer and better type of man discussed the moral issue much more directly and intelligibly, while the less attractive men of the class saw the physical relationship of venereal diseases on their lives. On more than one occasion, one could read reflected in the answer the boy's own experiences.

The classification attempted is merely a tentative one but it shows in general the reaction of students to the movie. Of course, a number of different points will be brought out in individual papers. At the close of this brief analysis, a number of individual papers will be quoted, so that the reader may get some first-hand knowledge as to the boys' answers to the questions.

The strongest appeal was the argument for clean living.

Thirty-three of the class showed that this argument appealed to them. Five said it showed the "effect of clean living on social relationships"; three, it showed "the joy of clean living"; five that it showed the "importance of health, honor and cleanliness"; two said "it pays to keep straight and clean." The direct moral appeal was cited by twenty-one students. Two said "it shows us how to resist temptation"; two "it shows the value of self-control"; six "it shows the need of living a continent life"; four say "it teaches the woman's side"; two "it teaches the woman's place, how she should hold herself when with young men." Under the direct note of the physical relationship, the harm of sexual diseases made the most impression. Fifteen boys said "it showed them the seriousness of sexual diseases"; fifteen "that it showed the effects of evil living on the wife"; eight "the effects of evil living on the children"; eighteen referred to the terrible, or awful, effects of syphilis in its final stages; fifteen said "it discourages illicit intercourse"; two—"shows the results of illicit intercourse"; two—"shows the evils of illicit intercourse"; two—"shows that sexual intercourse is not necessary"; eight say "shows the effect of wild oats"; two—"sins of the fathers are visited upon the children"; two—"you pay the price." A number of the boys were impressed with some of the specific effects of gonorrhea or syphilis, and quite a number said that "they did now know certain things with reference to the diseases." For example, four gave some specific points in connection with syphilis or gonorrhea that they had not known before. Twelve mentioned the hospital cases shown by the picture and stated that "certain of those effects were new to them." Three mentioned the newness of the idea of early cure although several of the men who were in the army mentioned that this fact was known to them. Six said that "the picture impressed the fact that loose women were always diseased"; while five said that "it taught them to keep away from prostitutes." Two said that "it showed them to avoid physical contact"; one boy said "he did not know that physical contact was necessary"; five were surprised at the ease of infection; six said that "the picture cleared up or made more emphatic things that they already knew." One said that "it explained what his parents were unable to explain."

In the matter of training of children, it is interesting to find that twenty-one of the boys said that the picture emphasized the need for sex instruction when young (early—at right age).

Six said "it showed the value of proper sex instruction to children"; three said that "children ought to be told the truth about birth"; four said that "children should be taught before it is too late"; and several papers, especially those of the girls, emphasized the fact that "these teachings ought to come before high school age"; two said the movie emphasized the need of frankness on the part of parents"; one "on the part of teachers"; four "the effect of home environment" and one that "children should be told the temptations that they must conquer in later life"; four said it "was the result of lack of training of the parents." Two said that "much vice is due to lack of knowledge"; one that "ignorance is the cause of the most of the trouble"; one that "it teaches boys to tell the truth to their little brothers and sisters"; one that "it shows the way to bring up little folks"; one "it shows the danger of prudery."

The general contrast between right and wrong living was stressed in the case of a number of answers. Six said "it shows the difference between a clean and an immoral life"; three the difference between "good and bad living"; two "between right and wrong living"; two said it "contrasts the moral as well as the physical side."

Under the general head of love, matrimony, eugenics and social welfare might be placed some of the following answers: Six "it shows the vital responsibility of men to the welfare of the race." Nine "to the next generation"; three "it shows the effects of venereal diseases on society"; one "on women"; three "it shows that character, not physical beauty, is of most worth"; one "it shows that true love is superior to gross affection based on physical charm"; two "it shows the joys of true love"; two "what true love can accomplish"; one "what real love can bring"; one "real love does not always come early, but the only way to happiness is with a straight girl"; three "to raise a perfect family one must keep clean"; one "it shows the sacredness of marriage"; two "it shows that men are the real cause of the downfall of women"; one man, who I suspect had seen something of life, said that "women were the downfall of men"; one said "you should not marry until you know the person is of good character and clean body." Curiously enough, only two members of the class show that they understood that the picture stressed the single standard of morality and these two men did not actually use the term "single standard."

In the answers that follow, a few different papers have been

selected which show the reaction in different groups of students. The first papers are taken from some of the athletes of the class:

"The End of the Road" showed plainly the two paths in life a girl or boy may take; the lack of a little training on the part of the parents by not telling what was right and wrong in their early days. It also dealt with different diseases and how easily they were contracted and what it means to marry with these diseases. Sexual intercourse should only take place after marriage and should be kept sacred. The two girls started on an even basis and the one had it the best in youth, but at the end of the road it was different."

The second answer is from an outstanding athlete and one of the most popular men in college:

"The End of the Road" taught cleanliness. It did not teach me anything that was not taught before with one exception, that is to *help the other fellow.*"

Another athlete, a football man, well-liked in college:

"I think the movie taught us several important facts concerning sex life and sexual force.

1. That clean thoughts, clean companions, are an essential to every life.
2. That frankness in regard to sexual problems should be indulged in between parents and children.
3. That one way to become clean-minded is by education of the highest type.
4. The dangers and awfulness of venereal diseases.
5. These diseases once contracted can only be gotten rid of by the very best of medical attention.
6. That in the last analysis there is one and only one life to live and that is one of pure, clean and respectful life."

Another athlete, a football man:

"I think the 'End of the Road' a very good educational film. I knew before I saw the film most of the things that I saw, but it impressed me a great deal more than any talk. I got acquainted with those terms of the diseases and other things that were shown before, in a smutty way. It makes one think of what might have happened when we had that false impression and you thank God you passed through that period safely and make a resolution that you will watch your step much closer in the future. I think that, after seeing that film, we should have a different attitude toward women, who we all know has the hardest battle to fight. Men should protect the women and not help to push them down, as is done very often."

Another football man and ex-service man:

"The movie brought home to me the fact that it is our duty to live good, pure lives for the sake of other people, as well as our own. The great penalty of dissipation was shown clearly and made me realize more than ever the dangers of follies. It was a great inspiration for me to live a clean life and to help others to do so. We must all look forward to a home of our own some day, and I feel that we all must keep ourselves fit in our youthfulness. By ruining our own lives now, we may spoil the life of the girl we marry and also the lives of children, who may come to our home."

Another football and ex-service man:

"I learned nothing new from the picture, 'The End of the Road.' It merely brought home more forcibly the necessity for the reform for which it stands. The strongest point brought out was, that the child should be told the candid truth, without reservation, before it begins to develop sexually to any degree. The real truth of such matters does not strike

the average persons usually until he or she has attained manhood or womanhood, when in many cases, it is too late. I think this reform should be pushed as strongly, if not more so, than the liquor question."

The following papers are from some of the more attractive and higher standing men of the class:

"It seemed to me that the movie was primarily an educational film, designed especially to promote higher and better-living standards between the sexes. It was not merely a lesson on venereal diseases, but also a teacher of the finest type of culture and family relationships. It pictured, not only the horrors brought about by sin and loose living, but also the happiness and joy to be obtained by the proper use of one's family and social relationships. It was not merely a lesson of 'don'ts' but primarily a lesson of 'do's,' a lesson which taught proper methods of living, as well as how to avoid the improper, coarse, and vulgar methods."

This boy is one of the highest standing boys in college, is an ex-service man and is preparing for a life as a Medical Missionary:

"The picture is a strong argument for clean living. The moral is developed by contrast of the two characters. The greatest and most pointed contrast is produced in the first part during the commencement program. The picture was not exaggerated and has enough narrative to keep one's interest and yet was strong enough to leave a very strong impression of the moral long after the details have been forgotten. The picture gives a very high conception of what true womanhood may be and also what the right sort of man should be as portrayed by the characte of Major Bell. The picture brings out its truths in an open, frank way, tha goes right to the point without fear of criticism." t

Another high standing boy, an ex-service man from the farming district:

"I had seen the 'End of the Road' several times before. I think this picture, more than any other, teaches men and women to live clean lives, by showing what wrecks are made of human beings by living immoral lives, and by the abuse of the sex organs. It teaches young men to honor and respect chastity, purity and cleanliness. It makes clear that descendants from syphilitic parents are degenerated and can never be strong and healthy."

From a doctor's son:

"Any intelligent and thinking man came from that picture with a new view of sexual hygiene. First, he had vividly pictured to him the serious results of ignorance on the reproductive organs, contrasted with the child who is correctly informed as to their functions. One path led to misery and unhappiness, while the other led to complete happiness and perfect health. Secondly, the picture went further to show the *results* of ignorance about sexual intercourse, in terms of clap and syphilis. It pictured people whom syphilis had destroyed mentally and physically in comparatively no time at all; on the other hand, it showed the complete happiness of a continent life until wedlock. Lastly the picture left the impression that a man owed it to the woman of his dreams to lead a clean life for the period of ten years before he is married, for it is the 'slippers' who contract the disease."

Another doctor's son:

"The peculiar value of the 'End of the Road' seems to me to be this: That it appeals to the eye, not merely to the mind; one picture is more impressive than a hundred books. I think most people know the facts, but they are not impressed on them. This the picture did; and while it has the fault of attracting some for plain excitement, still pictorial

representation of such horrible facts certainly 'wakes up' the audience to the danger."

From a very fine and well brought up boy:

"The movie made a very deep impression upon me; in other words, it put on a second coat (in painter's language). It brought out the qualities of womanhood, which these girls possessed. The only way to happiness is the straight path. The horrible disease pictured shows the results of leading a familiar life with lewd women and how easy the sins of the father pass down to the son. It was a lesson which should be taught every young man and every young woman. How easy it is to become familiar, if one has not the right mental aspect. Parents should teach their young, instead of letting them learn it themselves, as they usually get the wrong conception. The picture showed what true, pure love can accomplish and what lust leads to."

The following are selected at random from members of the class who are about average students and who have not made any particular impression in college in any way:

"Before seeing the movie 'The End of the Road' I knew of the dangers of syphilis, etc,. but not of the results of the disease. The movie taught me nothing new, I might say, but simply accentuated and made clearer various points it portrayed. Before seeing the movie, I had read several resumes of it and also criticisms in papers and was of the decided impression that it was an *immoral, bad*, play to be given before a mixed audience. After seeing it, I am of the opposite mind and I saw nothing immoral about it. If all movies, handling the sex question, were as clear and absolutely devoid of the insinuation as 'The End of the Road' the public would be better off and I think a movie of this sort is decidedly an agent for good among persons of college age. It attempted no moralizing, no preaching, but the lesson sank in, I believe, to everyone seeing it. The fact that it had a plot, sadly lacking in most movies of this sort, was good, and made for more interest."

Another: "The picture impressed my mind with a number of things. I always had known that venereal diseases may break out on the skin, but I never believed it possible before, for such diseases to disfigure a person like they can. Also the contrast between a person living a clean life and one living an immoral life was brought out very strongly to me; showing the happiness of the decent girl and the sadness and shame of the immoral girl. Personally, I think that the picture helped me a lot and showed me many things I was ignorant of before. It is a picture that any person who saw it would benefit by."

Still another: "Practically all of the information given in the movie and perhaps more also that I was well acquainted with, due to lectures and sex talks in the army, also my experiences in a venereal ward in a base hospital. I have also learned considerable in connection with undertaking, especially of insane cases. Too much cannot be said with regard to sex matters, or too great emphasis laid upon the controlling of sex impulses. I have seen the horrible results of syphilis and know what it means. A full understanding between parents and children was well brought out in this movie. The outstanding feature in 'The End of the Road' in my estimation showed the necessity of frankness and openness in all matters between parents and children. The children should not be made to find out things concerning reproduction from unreliable sources. 'Ask Dad, he knows' would be a good slogan in this connection."

This shows a side light on the situation: "The movie 'The End of the Road' showed and proved the danger of prudery. It shows what became of the girl who was brought up with no knowledge of sex and compares her with the girl who was not denied the facts about sex. The movie also shows the results of young men's 'sowing wild oats.' It shows the unhappy end of such a life. It brings venereal disease, which is the result

of such a life, before the minds of the people and shows them the results which a vile life will bring forth. The pain and suffering of a man's wife and family who have either contracted a venereal disease from him or suffer from the effects of it (his sons and daughters) is shown very vividly."

The reproduction of these papers could go on indefinitely, and each would be as interesting as the last. It is evident that we are being judged by our peers. The consensus of young men of college age is clearly in favor of early sex teaching. What are we going to do about it?

NORTH CAROLINA ASSOCIATION.

The North Carolina Association of Teachers of Mathematics held its annual meeting, February 4 and 5, at the North Carolina College for Women, Greensboro, with Dr. A. W. Hobbs presiding.

Dr. J. W. Young of Dartmouth College, Chairman of the National Committee on Mathematical Requirements, was the guest of the association. The entire meeting was devoted to the discussion of the reports of the committee. The association heartily endorsed the suggestions of the committee as explained by Dr. Young and agreed to assist, in every way possible, its own committee in cooperating with the National Committee.

The program was as follows:

Friday, February 4, an address by Dr. Young on "The Reorganization of the First Courses in Secondary School Mathematics" (Circular No. 5). Social meeting.

Saturday, February 5, business meeting. Discussion of the report on Junior High School Mathematics (Circular No. 6), led by Dr. Young.

General discussion and action on the reports.

The officers for the year are: President, Dr. A. W. Hobbs, University of North Carolina (reelected); Vice President, Miss Nita Gressitt, Greensboro High School; Secretary, Miss Fannie Starr Mitchell, Gastonia High School; Treasurer, Mr. K. B. Patterson, Trinity College.

COURSES IN MATHEMATICS OF THE UNIVERSITY OF CHICAGO FOR THE SUMMER QUARTER, 1921.

The University of Chicago. First Term, June 20-July 27. Second Term, July 28-September 2, 1921.

By *Professor E. H. Moore*, Hermitian matrices of positive type, 4 hours, first term; determinants, 4 hours, first term.

By *Professor H. E. Slaught*, definite integrals, 4 hours; differential calculus, 5 hours.

By *Professor L. E. Dickson*, seminar on algebra and theory of numbers, 2 hours; solid analytic geometry, 4 hours.

By *Professor E. J. Wilczynski*, projective differential geometry, 4 hours; college algebra, 5 hours.

By *Professor A. C. Lunn*, applications of vector analysis to electromagnetism, 4 hours; units and dimensions, 4 hours.

By *Professor J. W. A. Young*, selected topics of mathematics, 4 hours; integral calculus, 5 hours.

By *Professor S. Lefschetz*, selected chapters of algebraic geometry, 4 hours; plane analytic geometry, 5 hours.

By *Professor Henry Blumberg*, functions of a real variable, 4 hours; plane trigonometry, 5 hours.

A GRAPHICAL SOLUTION OF EMPIRICAL RELATIONS OF ONE INDEPENDENT VARIABLE IN A FUNCTION CONTAINING FOUR UNDETERMINED CONSTANTS

By Walter Bartky,
Lewis Institute, Chicago.

Empirical relations are approximate relations between quantities obtained from experimental values of the quantities involved. This article will be devoted to the consideration of empirical equations of one independent variable in a function having four constants. A knowledge of elementary graphs is, of course, necessary. The equation of a straight line on rectangular coordinates can be expressed in the general form: $y=mx+b$, where x and y are the variables, b the intercept on the y-axis, and m the slope of the line. If points representing the values of two related quantities are plotted on rectangular coordinates and lie approximately on the same straight line, the empirical relation is of the form, $y=mx+b$, where x and y represent the quantities, while m and b are constants that are easily determined from the position of the line. Other empirical relations of one independent variable in a function having two constants can be reduced to the straight line form by letting x and y equal certain simple functions of the quantities involved.

Now consider an empirical equation of the form: $s=At^3+Bt^2+Ct+D$. A, B, C, and D are constants to be determined, and s and t are variables. Certain sets of values of s and t are obtained experimentally. It is desired to determine the constants of an empirical equation of this form for these values. Let s_1 and t_1 represent one pair of values of s and t. On rectangular coordinates where OX and OY are the axes, the line is plotted,

$$y=s_1. \tag{1}$$

Suppose this line is cut by a line the equation of which is

$$y=mx+b. \tag{2}$$

At the intersection of the two lines (1) and (2),

$$s_1 = mx+b \text{ or } x = (s_1-b)/m. \tag{3}$$

On another system of coordinates where OX' and OY' are the axes the line is plotted:

$$t_1 = (s_1)^2x'+y'. \tag{4}$$

Suppose this line is cut by a line the equation of which is

$$y' = m'x'+b'. \tag{5}$$

At the intersection of the two lines (4) and (5)

$$t_1 = (s_1)^2x'+m'x'+b'. \tag{6}$$

Now let the x of (3) be identical with the x' of (6), then substituting since $x = x' = (s_1-b)/m$,

$$t_1 = [(s_1)^3]/m - [b(s_1)^2]/m + [m'(s_1)]/m - (bm')/m + b'. \quad (7)$$

If for every set of values of s and t the same two sets of lines are plotted, namely:

$$y = s, \quad (8)$$

$$t = s^2x' + y', \quad (9)$$

and if each set of lines, (8) and (9) is cut by a line of form respectively,

$$y = mx + b, \quad (10)$$

$$y' = m'x' + b', \quad (11)$$

so that the values of x and x' for each corresponding pair of intersection points on lines (8) and (9) are approximately the same, then an approximate relation between s and t is,

$$t = (s^3)/m - (bs^2)/m + (m's)/m - (bm')/m + b'. \quad (12)$$

This is the same form as,

$$t = As^3 + Bs^2 + Cs + D. \quad (13)$$

In figure 1 a relation of this form is found between the following values of s and t:

	1	2	3	4
$s =$	0	.5	2	3
$t =$	5	3.4	5	27

For each of these four values four straight lines are plotted on x-y-axes from the relation, $x = s$, namely:

(1). $x = 0$; (2). $x = .5$; (3). $x = 2$; (4). $x = 3$.

Also on x'-y'-axes four lines are plotted from relation.

$t = s^2x' + y'$, namely:

(1'). $5 = y'$. (2'). $3.4 = .25x' + y'$. (3'). $5 = 4x' + y'$.
(4'). $27 = 9x' + y'$.

The first and second sets of lines are cut, so that x and x' of the intersection points is the same for corresponding pairs of lines by the lines,

$$y = .5x + 1.5,$$

$$y' = -x' + 2.$$

Hence $m = .5$, $b = 1.5$, $m' = -1$, $b' = 2$.

Equation (12) becomes after substitution, $t = 2s^3 - 3s^2 - 2s + 5$.

In figure 1 it is readily seen that the lines (1), (2), (3), and (4) are parallel, likewise the lines AA', BB', CC', and DD'. Hence it follows by geometry that the line $y' = m'x' + b'$ must cut the lines plotted on the x'-y'-axes at distances, A'B', B'C', and C'D', proportional to the distances between the lines (1) and (2), (2) and (3), (3) and (4). This principle is used in figure 2, to determine the position of the line: $y' = m'x' + b'$. The same type of relation is found for the following values of s and t.

	1	2	3	4	5	6	7
s = (Specific Gravity.)	1.0	1.1	1.2	1.3	1.4	1.5	1.6
t = (Degrees Baumé.)	0.0	13.2	24.2	33.5	41.5	48.4	54.4

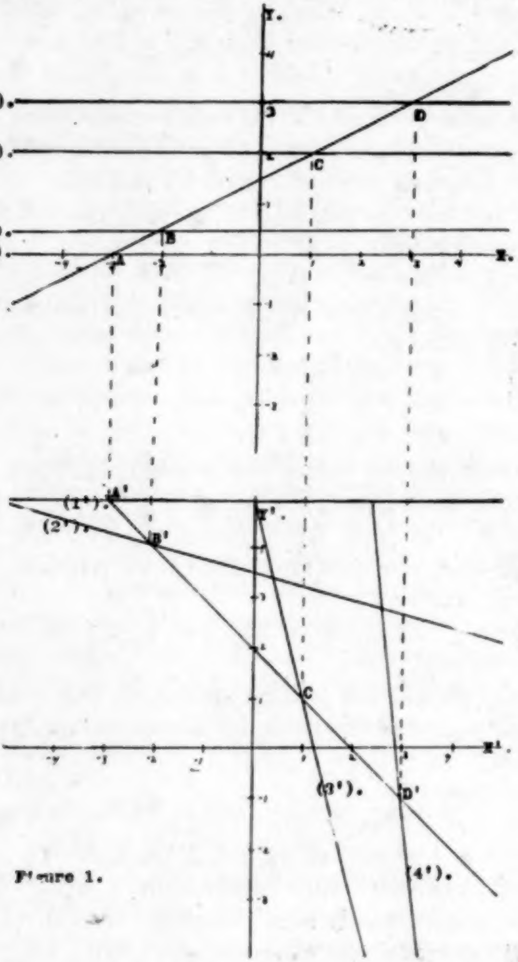


Figure 1.

As in figure 1, two sets of lines are plotted. In addition a set of parallel lines, (1″), (2″), (3″), etc., is ruled on transparent paper at distances proportional to the distances between the lines (1), (2), (3), etc. These parallel lines on transparent paper are then placed on the lines (1′), (2′), (3′), etc., and moved about until the intersections of each pair of lines, (1′) and (1″), (2′) and (2″), (3′) and (3″), etc., are approximately in the same straight line.

This line of intersections is the required line $y' = m'x'+b'$ since the intersections of the line on the lines (1′), (2′), (3′), etc., are at distances proportional to the distances between the parallel lines (1), (2), (3), etc. The position of the line, $y = mx+b$ is then easily determined since the value of x and x' for corresponding intersection points is the same. In this example different

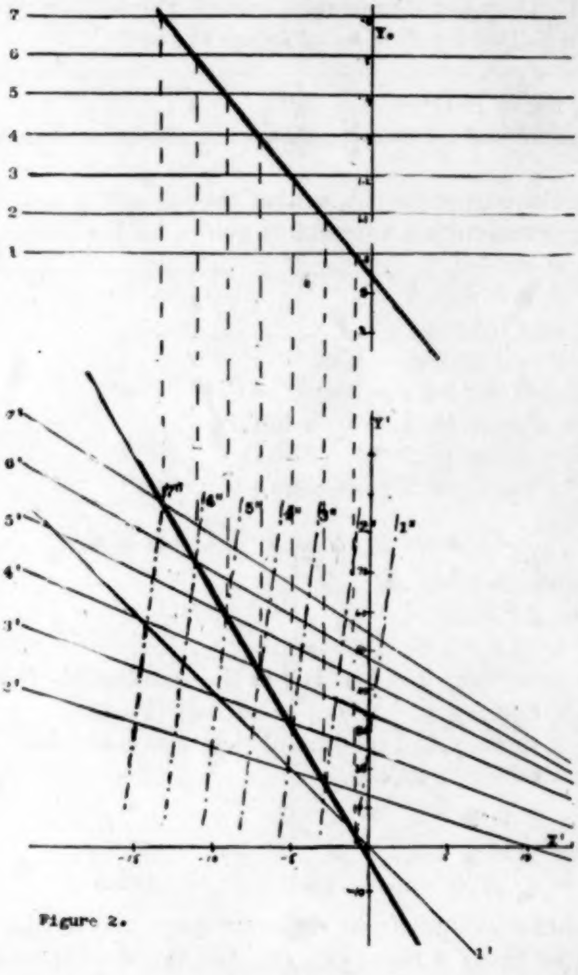


Figure 2.

units are used on the y-axis and the y'-axis, but the x-axis and the x'-axis have the same units. The two intersecting lines are,

$$y = -.048x+.95,$$

$$y' = -6.75x'-4.$$

Hence, $m = -.048$, $b = +.95$, $m' = -6.75$, $b' = -4$.

Equation (12) becomes after substitution,

$$t = -20.8s^3+19.8s^2+140s-139.$$

Now consider the empirical equation,

$$t = As^C+Bs^D,$$

in which s and t are the variables, and A, B, C, and D are the constants to be determined. Practically the same method is employed. On x-y-axes and on x'-y'-axes the following pairs of curves are plotted for each set of values of s and t,

$$s = e^y, \tag{1}$$

$$\log t = \log (e^{x'}+1)+y'. \tag{2}$$

(e the base of the natural logarithms or any other base may be used.)

As before the curves are cut, so that the value of x and x' is the same for corresponding intersection points, by the lines,

$$y = mx+b, \tag{3}$$

$$y' = m'x'+b'. \tag{4}$$

From (1) and (3), $s = e^{mx+b}$ (5)

or $x = 1/m \log s-b/m.$ (6)

From (2) and (4) $\log t = \log (e^{x'}+1)+m'x'+b'.$ (7)

Since $x = x'$ from (6) and (7) is obtained,

$$\log t = \log (e^{1/m \log s-b/m}+1) +m'(1/m \log s-b/m)+b'. \tag{8}$$

Simplifying,

$$t = e^{(b'm-b-bm')/m}\, s^{(1+m')/m} + e^{(b'm-bm')/m}\, s^{m'/m}. \tag{9}$$

This is the same form as,

$$t = As^C+Bs^D, \tag{10}$$

and $C = (1+m')/\mathrm{m}$, $D = m'/m$,

$A = \text{antilog } [b'-b/m\,(1+m')] = \text{antilog } [b'-bC]$,

$B = \text{antilog } [b'-m'/m] = \text{antilog } [b'-bD]$.

In figure 3 an empirical relation of this type is obtained for the following values of s and t:

	1	2	3	4	5
$s =$	1	2	4	10	20
$t =$	.176	.641	2.61	21.47	101.3

For the above values from the equation: $s = e^y$ the curves obtained in figure 3 are: (1), (2), (3), (4), and (5). Common logarithms are used and e is replaced by 10. These curves are parallel. Hence the same set of curves or parallels are plotted on transparent paper to aid in the solution, as explained in the example of figure 2, namely: (1″), (2″), (3″), (4″), and (5″). From the equation $\log t = \log (e^{x'}+1)+y'$, the curves obtained are: (1′), (2′), (3′), (4′), and (5′). In plotting these curves the

curve for one value of t is obtained. Suppose $t = 1$. Then $-y' = \log(10^{x'}+1)$. The curve for any other value of t is then easily obtained by lowering the x'-axis. The lines that intersect these two sets of curves making $x = x'$ are:

$$y = x + .4,$$
$$y' = 1.5x - .3.$$

Hence $m = 1$, $b = .4$, $m' = 1.5$, $b' = -.3$,

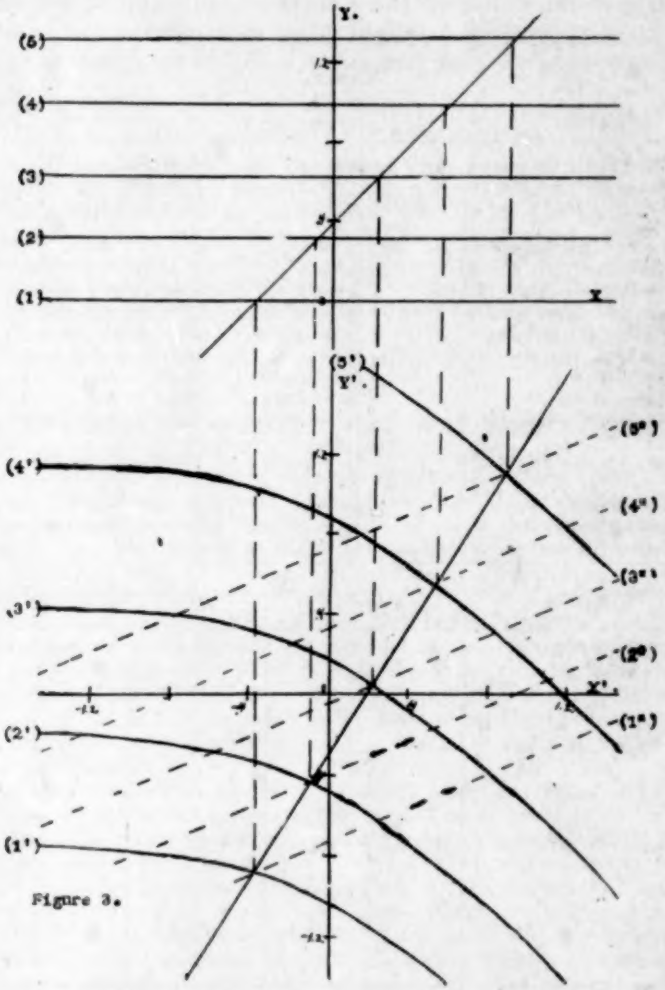


Figure 3.

$C = 2.5$, $D = 1.5$, $A =$ antilog $-1.3 = .05$, $B =$ antilog $-.9 = .126$, and $t = As^C + Bs^D$ becomes $t = .05s^{2.5} + .126s^{1.5}$.

The table is an aid in solving empirical relations of four con-

stants by this method. Different types of empirical equations are listed under equation. In these equations s and t are the variables. A, B, C, and D are the four constants that are to be determined. n, p, q, r, are known constants, the value zero included. The next two columns called x-y-axes and x'-y'-axes give the curves that are plotted on an x-y-axes and an x'-y'-axes for each set of values of s and t. The columns headed A, B, C, and D give the values of these constants in terms of the slope and y-intercept of the straight lines that cut the two sets of

TABLE.[1]

Equation	$x-y-axes$	$x'-y'-axes$
$t = As^3+Bs^2+Cs+D$	$y = s$	$t = s^2x'+y'$
$t = As^{3n}+Bs^{2n}+Cs^n+D$	$y = s^n$	$t = s^{2n}x'+y'$
$t = As^{3n+r}+Bs^{2n+r}+Cs^{n+r}+Ds^r+q$	$y = s^n$	$(t-q)/s\sqrt{\ } = s^{2n}x'+y'$
$t = As^{n+r}+Bs^r+Cs^{n+p}+Ds^p+q$	$y = s^n$	$t = s^rx'+s^py'+q$
$t = (As+B)^n(Cs+D)^r+q$	$y = s$	$t = (x')^n(y')^r+q$
$t = (As+B)^n+(Cs+D)^r+q$	$y = s$	$t = (x')^n+(y')^r+q$
$t = sin(As+B)+cos(Cs+D)$	$y = s$	$t = sinx'+cosy'$
$t = F(As+B, Cs+D)$	$y = s$	$t = F(x', y')$
$f(t, s) = F(t, s, q, As+B, Cs+D)$	$y = s$	$f(t, s) = F(t, s, q, x', y')$
$t = As^C+Bs^D$	$y = log\, s$	$log\, t = log(e^{x'}+1)+y'$
$t = As^C-Bs^D$	$y = log\, s$	$log\, t = log(e^{x'}-1)+y'$
$t = A(s+n)^C+B(s+n)^D+q$	$y = log(s+n)$	$log(t-q) = log(e^{x'}+1)+y'$
$t = A(s+n)^C-B(s+n)^D+q$	$y = log(s+n)$	$log(t-q) = log(e^{x'}-1)+y'$
$t = e^{As+B}+e^{Cs+D}$	$y = s$	$t = e^{x'}+e^{y'}$
$t = e^{As+B}-e^{Cs+D}$	$y = s$	$t = e^{x'}+e^{y'}$
$t = (As+B)^{Cs+D}$	$y = s$	$t = x'^{y'}$

A	B	C	D
$+1/m$	$-b/m$	m'/m	$(-bm'/m)+b'$
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
$antilog[b'-b/m(1+m')]$	$antilog[b'-m'/m]$	$(1+m')/m$	m'/m
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
$+1/m$	$-b/m$	m'/m	$(-bm'/m)+b'$
,,	,,	,,	,,
,,	,,	,,	,,

In any of the above examples s or t may be replaced by any function of s and t.

For example, s or t may be replaced by s^2, st, $s+q$, $t+q$, $\sin s$, $\log t$, l^t, $t \log s$, etc.

[1]The second half of this table is a continuation, line for line, of the first half.

curves so that x and x' are equal. If one of the sets of curves is a series of parallel lines then transparent paper with these parallel lines may be used in determining the position of the intersecting lines, $y = mx+b$, and $y' = m'x'+b'$.

Of course, this method is not as accurate as other methods involving advanced mathematics. It has its use in determining empirical equations of these types with a fair degree of accuracy and a minimum of calculations. Furthermore, in using this method there is very little restriction in selecting values of the quantities, four sets of values being sufficient for a solution.

RADIAL VELOCITY CATALOGUE.

A "First Catalogue of Radial Velocities" by J. Voute, of Java, Dutch East Indies, has just been issued. In this publication the author has compiled a list of the radial velocities of over 1900 stars and of 148 nebulae and clusters, thus bringing together material scattered through various publications. A catalogue of this nature will be of value for various statistical studies as it contains not only the radial velocity with the name of the observatory making the observations but also the magnitude, proper motion, type of spectrum, parallax when known, and the galactic latitude and longitude for each object listed.—[*Popular Astronomy*.

NEED TO CHECK CONSUMPTION AS WELL AS TO INCREASE PRODUCTION OF OIL.

The first thought in either a national or a world program for oil is to stimulate production; "more oil needed" described the symptom felt by every nation, and new and larger supplies of oil is the remedy sought. Taking the long view as well as the broad view, however, we are forced to admit the equal need of checking consumption. A world policy, if it is to safeguard the future, must draw up a program that will favor thrift in the use of the oil currently produced, and in that program also there must be a joining of the nations in continued effort for the common good. When the world runs short of oil all nations will suffer, regardless of the geographic location of the remaining wells. America has led in teaching the world to use petroleum, whether in lamp or automobile or tractor, and it should be America's special duty to teach the world to use petroleum most efficiently.

The oil problem can be solved only through a keener realization of the world's future needs and a stronger determination to serve future interests. Any taking over of the rules of war into the economic competition for new supplies of oil or for markets for oil products will waste a limited resource as well as threaten world peace. If a high executive of one of the largest steel companies can address the American Iron and Steel Institute on the Golden Rule in Business the same thought may well be given this wider application before the American Petroleum Institute. Diplomacy—whether old world or new world—can offer no better guide in these questions of world economics than is found in the Golden Rule. No other theory of international conduct is so worthy of a democratic nation or can be so easily applied to practical issues, and its application to oil is absolutely necessary if we are to make the world's oil serve the greatest number of generations.—[U. S. Geol. Survey.

THE ACHIEVEMENT OF HIGH SCHOOL AND FRESHMAN COLLEGE STUDENTS IN CHEMISTRY.

By S. R. Powers, Director of the Training School.
University of Arkansas.

During May, 1920, two chemistry tests, described below were given in 20 high schools located in the central and north-central states. The enrollment in the high school classes taking the test varied from 5 to 171. The tests were also given to two groups of Freshmen enrolled in the chemistry classes in a large mid-western university. These students were at the point of finishing the Freshman work in university chemistry. One of the Freshman groups consisted of 168 engineering students, 151 of whom had taken one year of high school chemistry before entering the university. The second Freshman group consisted of 57 students, none of whom had taken any chemistry in high school.

This preliminary report is limited to results obtained from four large schools and from the two groups of University Freshmen, or in all six groups of students. Each of these groups, except the university Freshmen who had not taken high school chemistry, took both of the tests. This group of the university Freshmen took only the part of the test described below as Test I. The four high schools were located in four different states. The designation of these groups used in this report together with the number of students in each group is:

School	Cases
A	46
B	81
C	121
D	171
U	168
Ux	57

The group designated U represents those university Freshmen, who had taken chemistry in high school, and the group Ux represents those Freshmen who had not taken chemistry in high school. Each of the university groups was tested just before the end of one year's work in college chemistry.

The tests were circulated from the University of Minnesota. They were designated as Test I and Test II. It was intended that each test be of such length that it would require one class period for students to finish. The time element was not considered in scoring and it was intended that students should not feel unduly rushed while taking the test. The examiner hoped that the student would feel when he handed in his paper that he had

answered as much of the test as he was able to answer. The results of the testing show that most of the students taking the test were allowed ample time.

As respects the material constituting them, the two tests differed from each other quite distinctly. Test I called for ability to perform more or less mechanical operations and involved the use of formulas and equations. Test II tested the student's range of informational facts, which he had been taught in the chemistry course.

Test I was divided into eight groups of items. It seems inadvisable to reproduce the complete tests here. The nature of the test will be clear, however, from the following, which are the instructions as given for each group of items, together with one item for illustration. The number of items in each group is also indicated.

TEST I.

I. Write the names of the following compounds:
   1. Hg O (Ten formulas constitute Group I)

II. Write the formula for the following substances:
   1. Calcium oxide. (The names of ten substances constitute Group II)

III. The valence of the following elements and radicals are as indicated. Write the formula for the oxide, bromide, sulfate, and phosphate of each metal.
   Mg^{++}s O^{--} (The valence of five positive and four negative radicals are indicated and space is left for the student to write 20 formulas.)

IV. Arrange the following elements in order of the activity series (displacement series). (The names of 10 electropositive elements are given and blanks left in which the students are to arrange them in order.)

V. Place a letter C before each substance listed here if it is a compound, a letter E if it is an element, and a letter M if it is a mixture.
   1. ——Cane sugar. (The names of 20 substances constitute the group.)

VI. Fill in the right hand side and balance each of the following equations:
   $Zn + H_2SO_4 \rightarrow$ (Ten equations constitute the group.)

VII. Write the equation for each of the following chemical changes:
   1. The preparation of oxygen from potassium chlorate. (Ten chemical changes are named and space left for the equation for each.)

VIII. Write one equation to illustrate each of the following types of reactions:
   1. Simple addition. (Illustrations are asked for five types of reactions.)

The nature of Test II is made clear by the statement of the instructions to the students together with the illustrations. The instructions are: "This is a test of range of information about chemistry. In each of the following statements you have five choices for the last word. Only one of them will make the

sentence correct. In each sentence draw a line under the one of these words which makes the truest sentence. Notice the sample sentences:

Water is a compound of hydrogen and zinc nitrogen oxygen helium chlorine.

The word oxygen is underlined because it makes the truest sentence. Complete as many of the sentences as you can."

1. The oxygen of commerce is made chiefly from water potassiumchlorate barium peroxide liquid air sodium peroxide. (One hundred such incomplete sentences constitute Test II.)

The tests were scored by recording the number of times each item in each test was answered correctly. A detailed report, showing the score on each of the 195 items included in the two tests, would occupy more space than the conditions under which this preliminary report is published could justify. This summary report gives only averages and medians.

In Table I is shown the percent of perfect scores made by each school on each of the eight groups of items of Test I. For example the 80 at the head of the first column means that 80 percent of the answers made to the ten items in group I of Test I by the students in school A, were correct.

TABLE I.

Cases: A-46; B-81; C-110; D-165; Total H. S.-402 U.-158; Ux-57.

Part	1	2	3	4	5	6	7	8	Av.
A.	80.0	49.1	86.4	41.0	64.3	48.2	31.0	45.6	55.8
B.	73.3	40.7	81.1	53.3	54.0	44.2	28.1	45.4	52.5
C.	73.1	56.0	88.3		68.6	44.0	29.5	53.6	59.0
D.	56.7	31.8	58.5	28.5	67.0	27.6	16.0	51.0	42.1
Av.	66.9	42.0	74.0	37.2	64.5	37.5	29.5	50.0	50.2
U.	86.3	67.1	95.1	34.9	82.5	60.1	44.8	70.8	67.7
Ux.	80.7	51.2	95.8	54.8	78.6	52.6	33.6	65.2	64.0

The highest score of the high schools was made on the items in Group III which calls for ability to write formulas from given radicals and their valences. The next highest score was made on Group I which called for ability to write the names of compounds from given formulas. The third highest score was made on Group V which called for ability to classify elements, mixtures and compounds. On only these three groups of items was the percent of correctness higher than 50. The lowest score was made on the items grouped under VII. These items called for ability to write equations from the name or description of given chemical changes.

The differences between the highest and lowest high school scores on Test I, between the scores of the two university classes

and between the highest high school score and each of the university classes is important for purposes of comparison. These are shown in Table II.

TABLE II.

Difference between lowest and	I	II	III	IV	V	VI	VII	VIII	Ave.
highest H. S.	23.3	24.2	29.8	25.8	14.6	20.6	15	8.2	16.9
highest H.S. & U.	6.3	11.1	6.8	18.4*	13.9	11.9	13.8	17.2	8.7
Highest H. S. & Ux.	0.7	4.8*	7.5	1.5	10.0	4.4	2.6	11.6	5.0
U and Ux.	5.6	15.9	0.7	19.9†	3.9	7.5	11.2	5.6	3.7

*High school ranked highest.
†Ux ranked highest.

It is interesting to note that in seven of the eight groups of items the range between the highest and the lowest high school scores is much greater than the range between the highest high school and either of the university scores. On six of the eight groups of items the university students who had had high school chemistry did considerably better than those who had not had high school chemistry. We do not have in this any basis for definite conclusions, but if ability to answer the items given in Test I is any index of general ability in chemistry, we may well question whether the criticisms of high school chemistry teaching made by university chemistry teachers has any scientific foundation. When we recognize further that those students who finish the Freshman year in a university represent a much more highly selected group as regards ability to do school work than those students enrolled in our high school classes and when we consider that the equipment furnished by the university is usually superior to that of the high schools and thirdly, that the university students are actually required to devote more hours per week to chemistry than high school students devote, it would seem that, given these just named conditions equal, measured in terms of Test I, the product from our high school classes in chemistry is not materially different from the product from our university Freshman classes.

Table III is inserted to show the average scores made by boys and girls on each of the eight groups of items in Test I.

Only in school D were the girls able to excel the boys and here only in two groups of items. It may occasion some surprise to see that in these more or less mechanical operations the boys should so consistently excel the girls.

Test II requires a somewhat different ability than that required for Test I. This test is supposed to measure the student's range of information about chemistry; it is presumed to give a relative measure of the number of facts about chemistry which

the student has learned. Students deficient in the ability required for this test have probably profited but little from their instruction. It is hardly conceivable that they could succeed in any test if they were lacking in information.

TABLE III.

Schools	Cases b.	Cases g.	I b.	I g.	II b.	II g.	III b.	III g.	IV b.	IV g.
A.	21	25	84.8	76.0	58.5	41.2	91.0	82.0	43.8	35.2
B.	53	28	77.9	64.6	44.0	34.3	82.0	80.5	59.0	41.8
C.	65	55	76.0	72.5	63.9	55.7	83.5	90.0		
D.	65	90	61.1	55.5	29.2	32.5	62.0	59.0	31.2	28.9
Av.	204	198	73.6	64.1	44.1	39.8	64.5	67.0	46.0	32.3

Schools	V b.	V g.	VI b.	VI g.	VII b.	VII g.	VIII b.	VIII g.
A.	72.5	59.5	56.6	42.8	43.8	20.4	55.6	36.0
B.	72.5	60.5	49.0	33.8	31.3	14.6	54.0	26.4
C.	70.5	67.0	46.3	43.8	30.9	28.9	56.8	51.8
D.	65.5	61.5	30.7	25.0	17.0	15.2	51.2	47.8
Av.	69.0	62.5	43.1	36.2	27.9	19.6	54.4	44.0

The median scores made by each of the schools and by the boys and girls in each school together with the number of students taking Test II are shown in Table IV.

TABLE IV.

Schools	Group Med.	Cases	Girls Med.	Cases	Boys Med.	Cases
A.	47.3	38	42.0	19	56.0	19
B.	41.2	80	39.0	30	44.0	50
C.	38.0	108	38.0	52	37.0	56
D.	38.9	171	37.5	92	39.5	62
Av.	39.1		38.2		41.5	
U.	56.5	168				

Only the group of university students who had taken high school chemistry took Test II.

In Test II as in Test I the difference between the median scores made by the university and high school students was not great. The range between the highest and lowest median scores made by the high schools is just equal to the range between the highest high school median score and the median score of the university students. It is noteworthy that in Test II as in Test I the boys scored uniformly higher. In school C, the single exception, the median of the girls is one point higher than the median of the boys.

The relation between the ages of the students and their test scores is interesting and probably significant. Table V shows this relation. Only data from schools B, C and D are used in this table. Notice that the younger students uniformly make the highest scores. The 20 year old group consisting of but 16 students constitutes the sole exception. These students scored higher than the 18 and 19 year olds but lower than all others.

The facts shown here are, however, as one would expect them to be. It takes an intelligent youngster to make enrollment in the chemistry class, a junior or senior subject, by age 15. With the degree of intelligence that could win this rapid promotion the youngest students should make the highest scores when given any sort of objective tests. The age scores in Table V are averages.

TABLE V.

Av.	15yr.	Cases	16yr.	Cases	17yr.	Cases	18yr.	Cases	19yr.	Cases	20yr.	Cases
B.	44.3	3	40.5	19	43.6	26	43.4	25	29.2	4	45.9	3
C.			39.9	20	37.3	34	33.3	37	31.3	12	32.6	3
D.	46	4	42.5	22	39.5	62	37.1	43	40.6	15	38.6	10
Av.	45.2	7	41.0	61	39.8	122	37.2	105	35.5	31	38.8	16

It is a significant fact to chemistry teachers that the order of difficulty of the various items of the test in different schools is nearly the same. Those items found to be most difficult by one school were generally found to be most difficult by all schools. This fact is strikingly illustrated by arranging the scores, which were made on the various items of the test in rank order, and determining the correlation between the numbers expressing this rank order in different schools. In Test I the items of each division of the test were rank-ordered according to the score on each item and the correlation between the numbers expressing the rank order determined for three schools. These values are shown in Table VI. It was impossible to give a rank order for the items in division III and IV.

TABLE VI.

Correlation between schools	Divisions of the Test I	II	V	VI	VII	VIII
A and B	.77	.88	.79	.94	.77	.98
B and D	.84	.92	.50	.94	.72	.90
A and D	.80	.88	.57	.86	.74	.60

The order of difficulty for the items in divisions I, II, VI and VII which call only for knowledge of formulas and equations is more nearly the same in the different schools than for the items in division V which calls for ability to classify elements, mixtures and compounds. The factors under number VIII are not significant for the reason that there are only five items in this division.

The relation between the order of difficulty for the items in Test II was determined in the same way. The scores made on each of the 100 items of the test in each of the four schools were put in rank order. The numbers expressing this rank order in the different schools were then correlated. The values obtained

are shown in Table VII. The formula used for calculating these correlations and also those in Table VI is: $r = -\frac{6 \text{ sum } d^2}{N(N^2-1)}$, r is the correlation factor, n is the number of cases and d is the difference between numbers expressing the rank order.

TABLE VII.

Correlation between schools	r
A and B	.47
B and C	.50
B and D	.55
C and D	.54

The following illustrations will make clear the significance of the factors in Table VII. In determining these values it was necessary to determine by subtraction the difference between the numbers used to express the rank orders of difficulty of a given item in the two schools between which the correlation was determined. For example, if one item in the test was found easiest in one school that item would be given rank one in that school. If it was found most difficult in another school it would in this school be given rank 100 (100 items constitute the test). The difference between the numbers expressing the rank in the two schools would be 99. If the order of difficulty for a given item is the same in two schools the difference between the numbers expressing the rank would be zero. In determining the correlation between schools A and B, the case in which the correlation factor is lowest, it was found that 31 of the differences between the numbers expressing the rank orders were less than 10; 51 differences were less than 20, and only 13 were greater than 50. In determining the correlation between B and D, in which the factor was found to be greatest, 34 of the differences between the numbers expressing the rank orders were less than 10; 62 were less than 20 and but 5 were greater than 50. It would seem, therefore, that those points of information which are emphasized in one of these schools are also emphasized in the other schools. Certainly the agreement between these schools as regards course content is surprisingly high.

This paper is presented for the purpose of giving results of the test. However, it is difficult to refrain from adding comment. There is occasion for surprise that students do so poorly on certain parts of the test and so well on other parts. Test I shows that only 76 percent of the students in these four high schools knew that air was a mixture. Only 53 percent knew that coal gas was a mixture. Only 12 percent of these students were able

to complete our pet equation for the preparation of sulfur dioxide from copper and sulfuric acid. Only 5.3 percent were able to write the equation to represent the laboratory preparation of ammonia, using ammonium chloride. The students found it very easy to recognize or to write the formula of the common laboratory reagents but found difficulty with any that were unusual. The part of Test I that occasioned greatest difficulty was that of writing the equation for a chemical change when there is given the name or description of the change (Group VII). The difficulty experienced by both the high school and university groups with the items in Group VII would seem to indicate either that teachers are not trying to develop this ability or that the realization of this ability lies beyond the capacity of high school students.

Test II is of sufficient importance to merit a detailed report on each of the 100 items in the test. However, it seems advisable to withhold such a report until the test has been revised. This report will mention only particular items. The point in this test that was most generally known was that water may be separated into hydrogen and oxygen by electrolysis. Ninety percent of all the students in the four schools answered this point correctly. The question of whether or not air is a mixture is next in order of difficulty. Eighty-four and one-half percent of the students answered this correctly. The third point in order of difficulty required the student to say what part of a liter 200 cubic centimeters is. Eighty-four percent answered this correctly. One can scarcely understand how 16 percent of the students enrolled in four of the best high schools in the United States could fail when asked to answer these second and third points and that 10 percent should miss the first one.

The point of greatest difficulty required that the students tell whether gas mantles were made from asbestos, thorium oxide, magnesium oxide, thermit or styptic cotton. Only 6.7 percent of all the students answered this point correctly. A surprisingly large number answered styptic cotton. Next to the most difficult was the fact that wool contains sulfur in chemical composition while silk does not. Eight and six-tenths percent of the students were familiar with this fact. Whether or not palmatin is contained in butter, soap, petroleum, coal tar or slag, with eleven percent of correct answers, was next in order. The average of the median percent scores on Test II in the four schools is 39.1.

The teachers who gave the tests were asked to rate their students on three items, namely, scholarship, industry and intelligence. Scholarship was defined in terms of achievement. Teachers were asked to rate those students who had actually learned the most about chemistry as highest in scholarship. They were asked to rate the most industrious students, that is, those who tried hardest, as highest in industry, and to rate the most intelligent, that is, those who learn with least effort, as highest in intelligence. The ratings on each quality were made in terms of A, B, C, D, and E. The teachers were guided in making their ratings by the following instructions:

Scholarship: In rating a pupil in scholarship, think about how well he does in his school studies. If he is average, mark him C. If he is as good as the best 5 percent of children you have known in the public school, marks him A. If he is better than the poorest 75 percent of the public school children you know, but not so good as the best 5 per cent, mark him B. If he is poorer than the best 75 per cent you have known, i. e., poorer than the middle 50 percent, but not so poor as the poorest 5 percent, mark him D. If he is as poor as the poorest 5 percent of children in the public schools, mark him E. Proceed similarly with every other child on the list.[1]

No ratings were made by school A. Those from schools B and C were incomplete, only about half the students of each school were rated. Only from school D was a rating furnished for each student taking the test. In tables VIII and IX are given the median or average[2] test scores and the range of scores falling within the middle 50 percent of the scores made by the students coming under each scholarship rating. In other words, 25 percent of the students falling under each scholarship rating made poorer and 25 percent made better than the lowest and the highest score given in the tables under range. Table VIII shows the results from Test I and Table IX shows the results from Test II. The total score for Test I was gotten by adding the scores made on each of the eight groups of items which constitute the test. The possible total score is 95. The scores on Test II were gotten by adding the total number of correct answers which the student made on the test. The total possible score is 100. Table X is arranged in the same manner as Tables VIII and IX. It differs in that the scores in this table were obtained by adding the scores made on Test I and Test II.

[1] These instructions were taken from a form used by the Virginia Survey Commission.
[2] Averages were computed when the number of cases was small.

TABLE VIII.
Test I scores

Teachers' ratings	A			B		
Schools	Cases	Med	Range[2]	Cases	Med	Range
B	5	76.4	74–80	12	58.0	51–67
C	4	63.0	....	7	56.8	58–62
D	30	47.0	40–55	34	41.4	36–45

Teachers' ratings	C			D			E
Schools	Cases	Med	Range	Cases	Med	Range	Casse
B	26	47.5	35–54	3	42.0	....	0
C	16	53.6	48–63	24	50.5	40–57	1
D	69	37.2	33–41	26	32.3	29–39	2

TABLE IX.
Test II Scores

Teachers' ratings	A			B		
Schools	Cases	Med	Range	Cases	Med	Range
B	5	53.4	....	9	43.1	36–47
C	3	46.6	....	6	41.0	....
D	29	60.5	52–68	33	49.6	36–57

Teachers' ratings	C			D			E
Schools	Cases	Med	Range	Cases	Med	Range	Cases
B	22	39.5	35–43	1	....	....	..
C	14	34.6	31–42	24	32.5	29–38	1
D	73	39.4	30–46	26	29.5	25–43	2

TABLE X.
Test I and II scores combined.

Teachers' ratings	A			B		
Schools	Cases	Med	Range	Cases	Med	Range
B	5	129.8	....	9	102.6	95–109
C	3	108.0	....	7	95.5	....
D	29	106.0	93–116	33	89.2	80–97

Teachers' ratings	C			D			E
Schools	Cases	Med	Range	Cases	Med	Range	Cases
B	23	84.0	77–97	1	....	....	0
C	14	88.8	69–105	24	82.5	69–91	1
D	70	73.8	66–84	26	63.0	60–77	2

The ratings from school D are most significant for the reason that the instructors here gave a scholarship rating for each student taking the test. The results from this school are illustrative and probably typical of what would be found in other schools. The amount of overlapping of the scores made on Test I by the students in the various scholarship groups of School D is clearly shown by Figure I. Figure II shows the same thing for Test II and Figure III represents the overlapping of the scholarship groups when the scores made on Test I and Test II are combined. A line representing the range of scores made on Test II by the university group is added to Figure II for comparison. The length of the lines represents the complete range between the highest and lowest score in each scholarship group. The heaviest cross bar on the line represents the position of the

[2]Range as used in this table means range of the middle 50 per cent of the scores made by the students taking the tests.

median score for the group. The distance between the two lighter cross bars on the line represents the range between the scores made by the students who make up the middle 50 percent of the group.

FIGURE I.

Range of scores, range of middle 50 per cent and the median score of students falling in each teacher's rating group. School D, Test I.

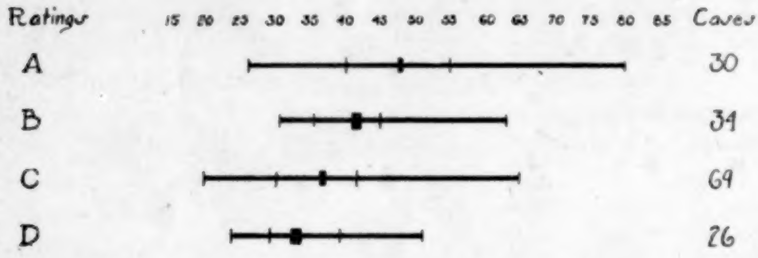


FIGURE II.

Range of scores, range of middle 50 per cent and the median score of students falling in each teacher's rating group, School D, and the range of score, range of middle 50 per cent and the median score of the University freshmen, Test II.

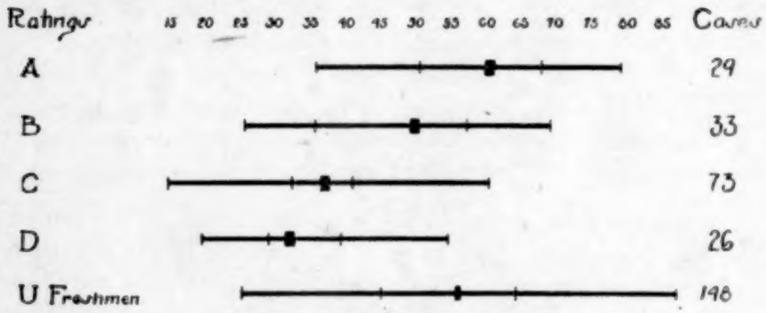
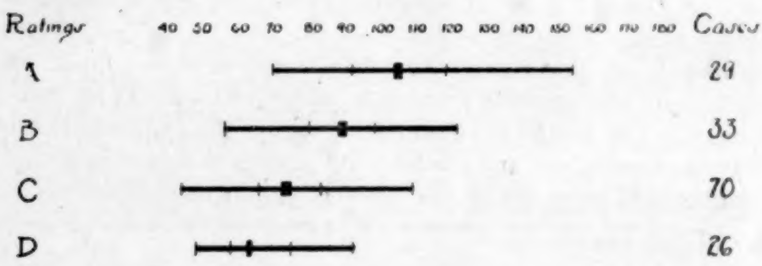


FIGURE III.

Range of scores, range of middle 50 per cent and the median score of students falling in each teacher's rating group, School D, Tests I and II combined.



The position of the median score for each group shows a general agreement between test scores and teachers' ratings for scholarship. The overlapping of the scores of the various scholarship groups may be due to many causes. In the first place, it is not assumed that the tests measure all those qualities which should be considered in making marks. It is conceivable that students who usually do well might do poorly on a single test. Adding the scores of the two tests should give a more accurate measure of the ability of individual students. The agreement between test scores and teachers' rating must be far from exact for the inaccuracies of teachers' estimates are well known. It seems quite likely, however, that these tests give a more accurate measure of the ability of individual students than any other single thing that could be used.

The results from our first experience with measuring the product from instruction in chemistry are most gratifying. On the basis of these results the tests are now being revised. The revised tests will be circulated near the close of the school year (1920-21) in what is hoped will be a final form.

The author of this study is very grateful, indeed, to those chemistry teachers who cooperated so generously by giving these tests and scoring the results. He sincerely hopes that when the revised tests are circulated the teachers will again lend their cooperation and thus make possible the formulation of a useful scale for measuring the results which accrue from giving instruction in chemistry to high school students.

AN ELEMENTARY DIFFRACTION METHOD FOR MEASUREMENT OF WAVE LENGTH

By J. K. Robertson,

Queens University, Kingston, Canada

When plane waves of monochromatic light fall on a small circular aperture and the emergent light is observed in an eyepiece placed at any position along a normal to the plane of the aperture, the diffraction pattern in general consists of alternately bright and dark circular rings with a bright or dark centre. If the eye-piece be moved from a considerable distance towards the aperture, it passes through fairly well-defined positions in which the central portion of the diffraction pattern is of maximum or of minimum intensity. Successive positions are somewhat as indicated in Fig. 1.

Now, by the method of half-period zones, it is easily proved that at positions of maximum intensity, $r^2 = n\, b_n \lambda$ ($n = 1$, 3, 5, etc.) while at positions of minimum intensity, $r^2 = n\, b_n \lambda$

FIGURE 1.

($n = 2$, 4, 6, etc.), where

r = radius of aperture,

b_n = distance from eye-piece to aperture,

λ = wave-length.

It follows, therefore, that a value of the wave-length may readily be obtained from measurements of b_n and r.

While only rough determinations of the wave-length are possible, the method gives results with, if anything, less variation than is often found in those obtained from a "Newton's Rings" apparatus. Moreover, it enables the student to calculate the wave-length of light *from two extremely simple linear measurements*, and, at the same time, by providing an elementary quantitative experiment on diffraction, is of value in clearing the frequently hazy ideas of the average student on this subject.

FIGURE 2.

In the actual experiment a pin-hole P, illuminated by a strong source of light, was placed at some distance from the circular aperture A, beyond which the emergent light could be observed in an eye-piece E, movable along a good optical bench. The source of light was either an arc lamp, before which pieces of ruby and of cobalt blue glasses were placed so that only a narrow portion of the red end of the spectrum was transmitted; or a mercury vapor lamp with the yellow lines filtered so that for visual observation the green line was the chief constituent of the transmitted light. As a rule values of b_n were obtained only for positions of minimum intensity, it being a trifle easier to observe positions at which the centre of the pattern was a sharp black dot than those of maximum intensity. A few of the latter, however, were also observed.

A summary of some typical measurements is given below. In all cases, the value of b_n given is the average of at least eight readings obtained by approaching the positions from both sides. It will be noted that two values of the wave-length are given. Those in the columns headed λ are calculated on the assumption that plane waves fall on the aperture. Obviously, unless the source is at a considerable distance from the aperture, this assumption is not justifiable, and, as a rule, it is necessary to take into account the distance R from the source to the aperture. Values obtained which in this way from the relation

$$r^2 = \frac{n\ \lambda}{\frac{1}{b_n} + \frac{1}{R}}$$

are given in the last column of the table.

Case I.

Source-Arc light filtered with red and blue glass.

R = 341. cm. r = 0.79 mm.

n	b_n	λ	λ'
4	23.6 cm.	.000066	.000070
6	15.5	.000067	.000070
8	11.6	.000067	.000070
10	9.42	.000066	.000068

Case II.

Source—Mercury vapor lamp with yellow lines filtered.

R = 205 cm. r = 0.79 mm.

n	b_n	λ	λ'
4	32.2	.000048	.000056
6	20.4	.000051	.000056
8	15.2	.000051	.000055
10	12.1	.000052	.000055
5	25.2	.000049	.000056
7	17.2	.000052	.000056
9	13.2	.000052	.000056

AN EXPERIMENT TO ILLUSTRATE THE CAUSE OF THE TIDES

By Wm. O. Beal,

University of Minnesota, Minneapolis.

In my experience as a teacher I have found that the cause of the phenomena of tides is grasped with difficulty by the average student of astronomy. To help the students form a clear and accurate mental picture of the nature of tides, as well as of their cause, it occurred to me to use a toy rubber balloon filled with water.

Place the neck of such a balloon over the faucet and run in about a quart of water. Support the ball of water on the extended palm of the left hand and give it a horizontal acceleration by a pull on the neck of the balloon with the right hand. This causes it to take on an elongated shape in the direction of the pull. It will be stretched not only on the side of the pull, but due to the inertia of the water within, it will bulge on the opposite side.

The attraction of the moon and sun acts in much the same way on the earth. But the earth is constantly rotating to the east causing the tidal bulges to travel round the earth to the west. The earth not being a fluid or even viscious, but quite rigid, yields only partially to the tidal strains, with the result that tides are produced in the oceans relative to the solid part.

If a smaller amount of water, say a cupful, be placed in the rubber balloon, and then tied to a cord, and whirled about in a circle in a vertical plane, the elongation of the balloon in the direction of the cord will be quite pronounced. This illustrates the permanent tides produced in the moon by the attraction of the earth, the rate of rotation of the moon equaling its average rate of revolution about the earth.

In this experimental illustration of the cause of the tides it will be borne in mind that the stretched rubber tends to keep the water in an approximately spherical form, whereas the rotating world is kept in an approximately spherical form by the mutual gravitation of its parts.

IMPROVISED SCIENCE APPARATUS

By Alfred Powers

University of Oregon, Eugene.

Home-made equipment, crude but satisfactory physics instruments are emphasized at the University of Oregon to the extent that instruction is offered in making them. This instruction is given in a course known as physics technics and is especially designed for those who would teach sciences in high school.

The course consists of the making of simple instruments that require no great amount of machinery in the manufacture. Soldering and glass-blowing are taken up. Vessels and tubes are made of glass. Resistances for use in electrical work are made by stringing wires on boards. Wheatstone bridges and meter sticks are manufactured. Galvanometers are made by winding coils of wire around boxes in which compass needles

are placed. In addition, many instruments are devised to assist in the study of light and sound, as well as in mechanical experiments.

One of the most notable pieces of work was the making of a pair of optical benches by an undergraduate. The set is used in the university laboratory for the study of lenses in connection with experiments in light.

The purpose of the course in physics mechanics is to teach the construction of apparatus rather than its use. Since the work is intended for those who expect to teach physics in high schools it is highly important that the prospective teachers be able to carry on laboratory work with many instruments of their own making. With this end in view, the majority of those who have taken the course have kept the apparatus which they have made. This practice of construction has also been followed by those doing research work.

It is the plan at present, according to Dr. W. P. Boynton, head of the physics department, to have a machine shop designed for instrument making. In connection with the shop there would be an expert in manufacturing apparatus. In addition to making instruments for the physics department, the man in charge of the shop would also make apparatus for other science departments of the university.

EUCLID DRAMATIZED.

By Margaret Graff,

South Philadelphia High School for Girls.

Whoever thought of dramatizing Euclid? This was done recently by girls of the South Philadelphia High School. The girls in two of the writer's classes in geometry, asked if they might not dramatize and present before the school some of the stories of early mathematicians told them in the course of their regular work in order that they might show the pioneer spirit in mathematics. They were told that they might do so if they wished and if they would work out their plans themselves. This they did faithfully, except at the end the head of the English department supervised a number of rehearsals and the head of the art department inspected the costumes. Their classroom teacher referred them to Ball's History of Mathematics, also Cajori's History and Smith's Teaching of Geometry. They found other material for themselves in various places.

The performance started with a five minute account of the life of Thales. Immediately afterwards, the curtain was drawn, revealing King Amasis seated upon his throne with two slaves back of him holding gorgeous fans and other attendants standing about. The king lamented that no one had been able to measure the height of the pyramids and promised to reward richly any one who could do this. One of the court then told the king that there was in their midst a Greek scholar who could do this by a simple method. Amasis commanded that the Greek be summoned.

Thales appeared and explained to the great satisfaction of Pharaoh his method of measuring the height of the pyramid by comparing the shadow of the pyramid to the shadow of his staff placed upright at the end of the shadow of the pyramid.

This truly beautiful scene was followed by an account of Euclid's life and his elements. This time the drawn curtain revealed a class of Greek students waiting for the great master Euclid himself. With two crossed sticks, Euclid demonstrated that the vertical angles are equal, using the modern method of the socialized recitation. Having finished, he asked if there were any questions. One youth then asked "Is there no easier way to learn geometry?" to which, of course, Euclid made his famous reply about there being no royal road to geometry. Another student wished to know what good gemoetry would do him anyway, and to him the master sent by the slave three pence because "he must be paid for all he learns."

The third scene followed an account of the life of Archimedes, the speaker stressing the fact that, while Archimedes was interested in mathematics for its own sake, his work had great practical results. Archimedes was shown drawing circles in the sand. When two Roman soldiers appeared, he called out to them not to disturb his circles. A soldier, ignorant who he was and thinking him merely insolent, killed him. The body was found by the Roman general Marcellus, who mourned his loss, paid tribute to his greatness, and vowed to erect a monument in his memory. The girls found an account of this as well as of the Thales story in Plutarch's Lives.

These three parts were prepared and acted by the girls of one geometry class, each member having a part as soldier, student, or attendant upon King Amasis. The girls themselves selected those with the best voices for the speaking parts, one of their number being stage manager as well as author of the scenarios. They had a beautiful time working out the parts and getting into the spirit of early geometry.

The last scene was given by eight girls of a different class. These girls decided that instead of giving a life and illustrating it in a scene, they would develop it as a lesson conducted by Plato himself in his famous Academy with the sign "Let no one ignorant of geometry enter my door." This scene was preceded by a delightful appreciation of geometry itself. The students were Eudoxus, Menaechmus, Aristotle, and others who discussed the life and words of Pythagoras. The climax came when Aristotle questioned Plato upon the occupation of Deity. To him Plato made his well known observations about Deity being the first to invent numbers, arithmetic, astronomy and geometry and that Deity continually geometrized. He then urged his class to go to nature to discover the truth of what he said.

GRACE JEAN BAIRD.

In the death, February 22, of Miss Grace Jean Baird, of the Bowen High School, Chicago, the biology teachers of the Central West have met with a great loss. Miss Baird took her Bachelor's degree at the University of Illinois and her Master's degree at the University of Chicago.

She was a very active member of the Central Association of Science and Mathematics Teachers, last year serving as Chairman of the Biology Section.

For sixteen years she had been a continuous subscriber to SCHOOL SCIENCE AND MATHEMATICS.

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg,

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

LATE SOLUTIONS.

679. *Dorothy Eaton, Student, Redlands H. S., California.*

SOLUTION OF PROBLEMS.

681. *Proposed by W. R. Warne, Pennsylvania State College, State College, Pa.*

ABC is a right triangle with the right angle at C. E is a point on AB, and D is a point on CB. ED is parallel to AC. CD = 10, DE = 15, and CB + BA = 100. Find the lengths of all the various lines in the figure.

Solution by Donald C. Steele, Greensburg High School, Pa.

Let BD = x. From the similar $\triangle$s ACB and EDB, $15 : AC = x : (10 + x)$ or $AC = (150+15x)/x$. Also $AB = 90-x$. Therefore

$$(90-x)^2 = [(150+15x)/x]^2+(10+x)^2$$

or $8x^3-311x^2+180x+900 = 0$. By Horner's method the roots are $x = 2.081$, $x = 38.209$ and $x = -1.415$. Taking the first value of x, the results are BD = 2.081, AC = 87.081, AB = 87.919, EA = $10x(90-x)/(10+x) = 72.774$. The second value of x gives BD = 38.209, AC = 18.925, EA = 10.743.

Similarly solved by N. Barotz, New York City, Michael Goldberg, Philadelphia, and Henry L. Wood, Corinth, N. Y. Using CB = x, *Moe Buchman, Brooklyn Boys' H. S. Math. Club,* and *Smith D. Turner, student at Parkersburg H. S., W. Va.,* were lead to the equation $200x^3-13{,}775x^2+220{,}000x-1{,}000{,}000 = 0$ whose roots, from the nature of the problem, must be 10 larger than the roots of the equation using BD = x; this shows how a happy choice for x may simplify our equations. *Hazel E. Schoonmaker, Augustana College, Rock Island, Ill.,* used AM = x, where M is a point on AC obtained by drawing a line through E parallel to CB. This gives $x^3+30x^2-7775x+30000 = 0$. AM is related to the other lines by the equation AM = 150/BD. The roots of this cubic are 72.081, 3.925, −106.007.

682. *Proposed by Thomas E. N. Eaton, Redland's High School, California.*

Solve
$$R\cos\theta + R\theta\sin\theta = 5.875 \qquad (1)$$
$$R\sin\theta - R\theta\cos\theta = .72 \qquad (2)$$

Solution by Norman Anning, Ann Arbor, Mich.

Dividing (2) by (1),

$.72/5.875 = (\tan\theta-\theta)/(1+\theta\tan\theta) = \tan(\theta - \text{arc}\tan\theta)$, or

$\theta = \text{arc}\tan(.72/5.875) + \text{arc}\tan\theta = .12194 + \text{arc}\tan\theta$.

Solving this transcendental equation roughly by means of a graph and then to a better approximation by tables, gives $\theta = .79146 = 45°20.8'$. To find R multiply (1) by $\cos\theta$, (2) by $\sin\theta$ and add, getting $R = 5.875\cos\theta + .72\sin\theta$. Hence R = 4.641. To check the results we substitute them in the equation $R\theta = 5.875\sin\theta - .72\cos\theta$ obtained by multiplying (1) by $\sin\theta$ and (2) by $-\cos\theta$ and adding.

683. *Proposed by Norman Anning, Ann Arbor, Mich.*

Find the nth term of the series 1, 2, 7, 11, 19, 26, 37, · · ·

I. *Solution by A. B. Hussey, New Rochelle, N. Y.*

The given terms may be regarded as the sum of the corresponding terms of the two series

$3/8, 21/8, 51/8, 93/8, 147/8, 173/8, 291/8, \cdots$
and
$5/8, -5/8, 5/8, -5/8, 5/8, -5/8, 5/8, \cdots$

The successive differences of the first are $18/8, 30/8, 42/8, 54/8, \cdots$ and the differences of these differences (so-called *second differences*) are constant, $12/8$. Hence the nth term is $(6n^2-3)/8$. The nth term of the other series is $-(-1)^n 5/8$. Therefore, the nth term of the given series is $[6n^2-3-5(-1)^n]/8$.

II. *Solution by T. E. N. Eaton, Redlands High School, Cal.*

Divide the given series into two sub-series, the first to consist of the terms $1, 7, 19, 37, \cdots$ and the second of $2, 11, 26, \cdots$ For the first sub-series we note that the 2nd term = 1st term$+6$; 3rd term = 2nd term$+2\cdot 6$; 4th term = 3rd term$+3\cdot 6$, or the nth term = 1st term$+(1+2+3+\cdots n-1)\cdot 6 = 1+3(n^2-n)$. But this term is the $(n+1)/2^{\text{th}}$ term of the original series. Hence the nth term (n odd) of the series is $1+3(n^2-1)/4$.

For the second sub-series (n even) we note

1st term	$= 2$	$= 2$
2nd term	$= 2+9$	$= 2+3+6$
3rd term	$= 2+9+15$	$= 2+2\cdot 3+2\cdot 6$
4th term	$= 2+9+15+21$	$= 2+3\cdot 3+6\cdot 6$
nth term	$= 2+(n-1)3+(1+2+3+\cdots n-1)6$	$= 2+(n-1)3+(n^2-n)3$

but this is the $n/2$nd term of the original series. Hence the nth term (n even) of the series is $2+(n^2/4-1)3$.

Similarly solved by M. Buchman, and M. Goldberg, stating the answer thus: $(3n^2+1)/4$ when n is odd, and $(3n^2-4)/4$ for n even.

III. *Solution by Gabriel Rousseau, student, Ecole Polytechnique de Montreal, Can.*

The successive differences of the terms are shown:

$$\begin{array}{ccccccccccccc}
1 & & 2 & & 7 & & 11 & & 19 & & 26 & & 37 \\
& 1 & & 5 & & 4 & & 8 & & 7 & & 11 & \\
& & 4 & & -1 & & 4 & & -1 & & 4 & & \\
& & & -5 & & 5 & & -5 & & 5 & & &
\end{array}$$

The given series is then written in terms of the numbers in this table:

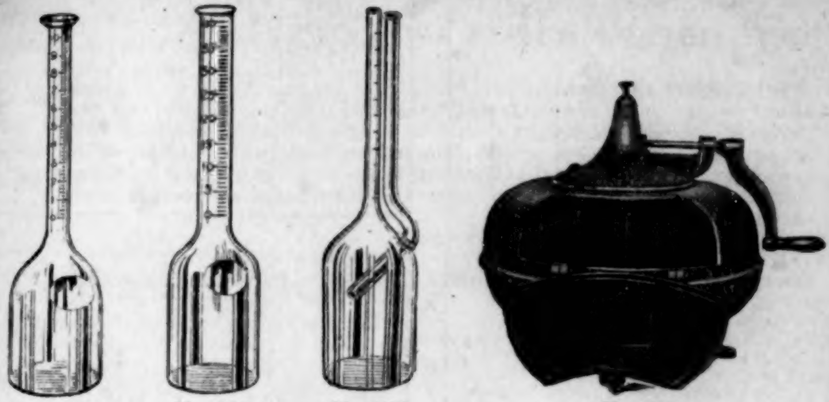
$$\begin{array}{rll}
1 &= 1 &= 1 \\
2 &= 1+1 &= 2 \\
7 &= 1+(1+5) &= 1+6 \\
11 &= (1+1)+(5+4) &= 2+9 \\
19 &= 1+(1+5)+(4+8) &= 1+6+12 \\
26 &= (1+1)+(5+4)+(8+7) &= 2+9+15 \\
37 &= 1+(1+5)+(4+8)+(7+11) &= 1+6+12+18
\end{array}$$

For n odd, the terms are $1, 1+6, 1+6+12, 1+6+12+18, \cdots$ or $(3n^2-1)/4$.

For n even, the terms are $2, 2+9, 2+9+15, 2+9+15+21, \cdots$ or $(3n^2-4)/4$.

IV. By using a recurrence relation, *H. E. A. Lazott, Nashua High School, N. H.*, found $u_n = u_{n-2m}+3m(n-m)$ where u_n is the nth term and $2m$ is the largest even number below n. Similarly *Hazel E. Schoonmaker* found $u_n = n+4[(n-2)+(n-4)+\cdots]-[(n-3)+(n-5)+\cdots]$ wherein the last term of the first bracket is 2 or 1 according as n is even or odd and vice versa for the second bracket. *N. Barotz* assumed the nth term to be $a+bn+cn^2+dn^3+en^4+fn^5+gn^6$, and then determined the coefficients by solving the equations obtained by putting $n = 1, 2, 3, \cdots$ The result is $a = 79$, $b = -536/3$, $c = 5375/36$, $d = -60$, $e = 455/36$, $f = -4/3$, $g = 1/18$. *J. Pickett, Ranger, Tex.*, obtained the same results, and adds that the problem should have called for *an* nth term instead of for *the* nth term as no series is ever determined by any given number of first terms since there can be an infinite number of series having their first terms to any desired number identical. Thus the series $1, 2, 3, \cdots$ may have for its nth term either n or $n^3-6n^2+12n-6$ or even $n^{(-n^2+5n-4)/2}$.

V. *Note by the proposer:*

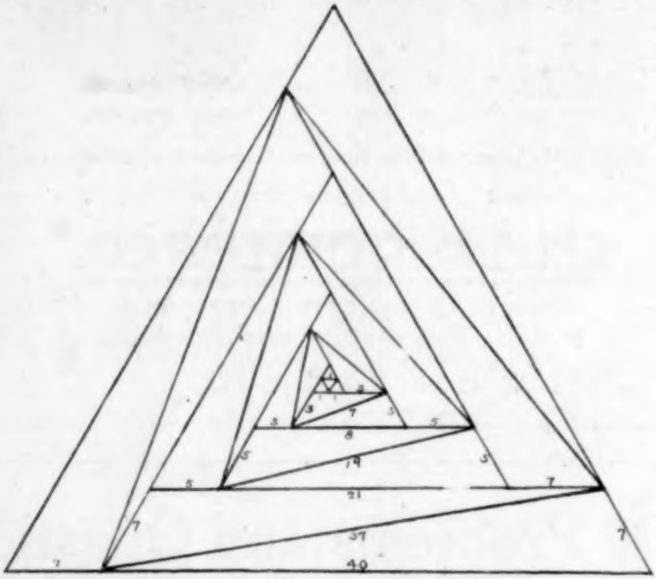


It has been pointed out by *Mr. Pickett* that the first few terms of a series afford no clue to the general term; that, while they may suggest one most probable value, equal weight should be assigned to all expressions which are satisfied by the given terms. The proposer admits the justice of this contention, but to show that the roots of the series in question go deeper than mere "puzzle my neighbor" offers the following geometrical interpretation:

Equilateral triangles whose sides are

1, 2, 7, 11, 19, 26, 37, $\cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot$ $\{6n^2-3+5(-1)^{n+1}\}/8$, $\cdot\ \cdot\ \cdot$

can be nested as shown in the figure. All distances shown are integral.



There are many other series of the same kind of which only one with general term $\{2n^2+4n+1+3(-1)^n\}/4$ will be mentioned. It holds for a set of nested squares.

To discover a series of hexagons and whether anything similar exists for other regular polygons are other interesting problems.

684. *Proposed by F. A. Cadwell, St. Paul, Minn.*

In *Wentworth & Smith's Plane Geometry*, problem 5, page 142, reads: "To construct a triangle having given one side, an adjacent angle and the difference of the other sides."

This is stated as though the size of the given angle was immaterial, but in the figure given to show how the construction is made the angle given is the lesser of the two angles adjacent to the given side.

In *Wells "Essentials of Geometry"* No. 55, page 226, reads:

"Given the base of a triangle, an adjacent *acute* angle and the difference of the other two sides, to construct the triangle."

Here, again, in the figure given to show the construction the angle given is the smaller of the two angles adjacent to the given side.

Hence, the following is proposed:

Construct a triangle having given the base, the difference of the other two sides and the greater angle adjacent to the base.

I. *Solution by Doris Brophy, Notre Dame Ladies' College, Montreal, Can.*

Given AB, $\angle$B, and d = AC − BC. Construct $\triangle$ABC.

Make $\angle$ABD = 180 − $\angle$B, taking BD = d. Join D to A, and draw its perpendicular bisector, cutting BD produced at C.

Also solved by N. Barotz, C. L. Hunly, Redlands H. S., California, Gabriel Rousseau, and Walter R. Warne, Pennsylvania State College, State

College, Pennsylvania, who also suggests a related problem (see 696 below). *H. E. A. Lazott* mentions that d must be less than AB when $\angle B$ is acute, and greater than the projection of AB on AD when $\angle B$ is obtuse; and for the case wherein $\angle B$ is the smaller instead of the larger base angle there are similar restrictions. The statement of the solution as given above is very good as it shows that we construct $\angle(180° - B)$ if $\angle B$ is the larger of the base angles, and $\angle B$ if it is the smaller. The following solution is an unusual one as it finds the unknown $\angle A$ before finding C. The figure is omitted here so that everyone will be induced to perform the construction.

II. *Solution by Michael Goldberg, Philadelphia.*

Make $\angle ABR = \angle B$; and with any point P, on BR, as a center and AP for a radius draw a circle. With A as a center and d for a radius draw a circle intersecting the previous one at F and H. Call E the intersection point of the line FH and a tangent at A to the first circle. From E draw a tangent EG to the circle whose center is A. The line AG extended is the third side of the desired triangle.

Proof. Since EF is a secant of both circles, $BE^2 = EF \times EH = EG^2$ or $EB = EG$. The point G is therefore on the circumference of a circle whose center is C and whose radius is BC. Then $AC - BC = AG = d$.

685. *For Undergraduates. Proposed by M. D. Taylor, Scott High School, Toledo, Ohio.*

Inscribe a square in a quadrant of a circle so that the diagonals of the square will be perpendicular to the two radii of the quadrant; also find the area of the square if the radius is r.

Solution by Irene Ricard, Notre Dame Ladies' College, Montreal.

Let OA and OB be the radii of the given quadrant. Draw AT $\perp$ to OA and $AT = 2OA$. Join O to T cutting arc AB at C. Draw CD $\perp$ to OA. Draw the perpendicular bisector of CD, cutting OB at E and the arc at F. Then DFCE is the required square.

If $OD = x$, then $DC = 2x$ since $\triangle ODC$ and OAT are similar, and $OC = x\sqrt{5} = r$. The area of the square is $2x^2$, or $2r^2/5$.

Also solved by Moe Buchman, and Gabriel Rousseau.

The editor is surprised at receiving so few solutions to such a simple problem. There is an experimental method which will solve or at least furnish clews to problems of inscribing one figure in another; for example, to inscribe a square in a triangle, one side of the square lying on the base of the triangle, we draw a small square (a sample of the desired goods) in one corner of the triangle. Then we let the square grow, so to speak, increasing in size and each side moving parallel to itself. What paths do the corners describe? Draw a small circle in each corner of a triangle, and then let each one grow in size; when will they coincide to form an inscribed circle? The same method can be used in problem 685; draw any square in the right angle of the quadrant with its diagonals perpendicular to the radii. If the square grows in size, how do the corners move? When inscribing a figure in a sector or semicircle or isosceles triangle, advantage should be taken of the symmetry of the figure, and the *sample* should be started growing from the point of symmetry. Frequently a proportion can be found which will suggest the solution; try this method of inscribing a circle in a sector of another circle.

PROBLEMS FOR SOLUTION.

696. *Proposed by Walter R. Warne, Pennsylvania State College, State College, Pennsylvania.*

Construct the triangle given $\angle A$, a, and the sum of b and c.

697. *Proposed by Earl W. Martin, Wilmington, Ohio.*

Squares with sides 1, 3, 5, 7, $\cdots\cdots$ are placed on a line so that their bases lie corner to corner. Show that their left upper vertices lie on a parabola and are at integral distances from the upper right hand vertex of the first square; and thus derive formulas for use in obtaining pairs of sides of right triangles whose sides are integral.

698. *Proposed by E. E. Waldrep, Birmingham Southern College, Ala.*

Find the ages of the people in the statement: When I was born my

sister was one-fourth mother's age but she is now one-third father's age. I am now one-fourth mother's age but in four years I shall be one-fourth father's age.

699. *Proposed by the Editor.*

In a given $\triangle ABC$, find a point P such that the 3 lines PA, PB and PC shall make given angles with each other.

700. *For Undergraduates. Proposed by Smith D. Turner, student, Parkersburg H. S., West Virginia.*

In a $\triangle ABC$, the altitude BD is drawn. $\angle ABC = 45°$, $AD = 9$, $DC = 6$; find AB, CB, DB.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

Ask for the questions you especially desire.

FOREIGN EXAMINATIONS.

The editor of this department desires to obtain examinations in NATURAL SCIENCE (as well as other subjects) from schools in France, Belgium, Italy, Spain, Denmark, Sweden, Norway and Finland. Any reader of SCHOOL SCIENCE AND MATHEMATICS in these countries will confer a great favor upon the editor by writing to him upon this subject.

Acknowledgment.

John Lundberg, Högre Realläroverkst, Goteberg, Sweden, has sent in an examination paper in *Physics* which is published in this number of SCHOOL SCIENCE AND MATHEMATICS. Mr. Lundberg says, "I am very glad to be able to send you the enclosed copy of the physical problems given last December in the 'Student Examen' in the Swedish schools, an examination the solving of which will give the boys and girls (aged about 18 years) entrance to our universities."

The readers of SCHOOL SCIENCE AND MATHEMATICS certainly appreciate this opportunity to compare the probable attainments of boys and girls in Sweden with those in this country. Thank you, Mr. Lundberg.

TESTS.

Sometime ago tests in physics and chemistry were prepared by the editor of this department of SCHOOL SCIENCE AND MATHEMATICS. Considerable interest was displayed by correspondents at the time. Due to circumstances the writer later was not in a position to make further applications of these tests upon classes. He would appreciate further assistance and will endeavor to cooperate with any who may be interested.

365. *The following test is proposed in continuation of tests published in January and March. Try the test on yourself and send in your time.*

Time————————min.

TEST M5. MACHINES-MECHANICAL ADVANTAGE-EFFICIENCY.

1. A lever of the second class is 8 inches long. The resistance is applied 1 inch from the hinged end. What force at the end of the lever will exert a force of 40 lb. on the resistance?

Ans.....................

2. A pulley system has 3 sheaves in the fixed block and 2 in the movable. What is its mechanical advantage? Ans.....................

3. An elevator bull wheel is 72 inches in diameter: the winding drum is 18 inches in diameter. The efficiency is 80 per cent. What force must be exerted to move a load of 2,000 lbs.? Ans.....................

4. A train and its load weighs 6,120 tons. The track rises 1 foot vertical in 4,000 feet horizontal. What is the least tractive pull the engine must exert? Ans.............................

5. The pitch of a jack screw is 1/2 inch, the length of its bar 28 inches measured from the center of the screw. What force can be exerted by a force of 80 lb.? ($\pi = 22/7$) Ans.............................

No.———. Attempts———. Right———. Wrong———.

PROBLEMS AND QUESTIONS FOR SOLUTION.

366. *Submitted by Philo F. Hammond, University of Wyoming, Laramie, Wyoming.*

("I tried this problem on a university class of 23 students in engineering physics, but none gave the correct solution.")

If a ball weighing 8 oz. is dropped 500 feet from the Washington monument, what is its velocity when it reaches the ground (neglecting friction of the air)?

If caught by a catcher on the ground, what force must he exert if the time is one second from the instant the ball hits his glove until it is stopped, assuming the force to be uniform?

If his hands move through a space of 4 feet in catching the ball, how much work does the catcher do?

EXAMINATION PAPERS.

367. *The following examination paper was sent in by Mr. John Lundberg, Högre Realläroverkst, Göteberg, Sweden. It has been translated by Mr. Carl R. Nilsson, formerly a student in the Göteberg High School, now in the Engineering Department of the Warner & Swasey Co.*

Mr. Lundberg says, "Time for the examination three and one-half hours. A candidate may obtain full marks by solving *at least two* of these problems absolutely correct."

Student Examination.

First Semester, 1920, Higher Real School (Högre Realläroverkst) Göteberg, Sweden.

Questions in Physics.

1. In a circular, homogeneous disc of uniform thickness cut a circular hole with a diameter equal to the radius of the disc and passing through the center of the disc. Determine three points on the periphery of the disc so located as to give equal pressure on these three points when the disc is in a horizontal position.

2. A string (without stretch) one meter long is held in a rigid support with a sphere attached at its free end. The sphere is then moved into such a position as to make the string horizontal. From this position it is released. At the moment that the sphere is directly below the point of suspension the string is cut, and the sphere is allowed to move unrestrained. At what point will the sphere touch the ground which is 6 meters below the point of suspension of the string?

3. A room 4 cubic meters in volume is filled with air at 20 C. and of relative humidity 90 per cent. Determine the weight of water condensed by lowering the temperature to 0 C.

The pressure of saturated water vapor at 20 C. is 17.4 m.m. of mercury, and at 0 C. 4.6 m.m. The specific gravity of air at 0 C. and 760 m.m. is 0.001293 and its coefficient of expansion 0.00367. The specific gravity of water vapor is 5/8 that of air at the same pressure and temperature.

4. A closed organ pipe 50 cm. long and a violin string sound at the same time. If the organ pipe gives its lowest note and the length of the string is 100 cm., two waves per second are produced. If the organ pipe gives the next to its lowest note and the length of the string is 34 cm., four waves per second are produced.

How great is the speed of the sound in air if the pitch of the string had been higher than the pipe in the first instance and lower in the latter? The string in both instances was stretched with the same weights and given its fundamental tone.

5. A person whose distance for clear vision is 24 cm. uses a converging lens as a reading glass. When the lens is held directly in front of the eye, the enlargement is 5/3 of that which is obtained when the distance between the eye and the lens is 10 cm. What is the focal length of the lens?

6. Connected in series by means of wires whose resistance can be combined are a battery, a galvanometer and a resistance wire whose resistance is 10 ohms. If another resistance wire of resistance 5 ohms is connected in parallel with the first resistance, the current is twice as great as before. Determine the internal resistance of the battery when the resistance of the galvanometer is 1 ohm.

7. Two small wax balls of the same size and weight are suspended by two insulated threads fastened at the same point. Length of threads 20 cm. each. If both wax balls are touched by a large conductor whose potential is P, and then taken away, the distance between the centers of the balls is 15 cm.

The experiment is repeated after the conductor has been charged to a new potential P_2. The distance between the balls is now 20 cm. Determine the relation between P and P_2 when one knows that the electric charge of a body is proportional to its electrical potential.

8. A battery and resistance wire form an electrical circuit with a combined resistance of 6 ohms.

How shall another resistance wire of 13 ohms resistance be cut in two different lengths so that, if either one is connected in series with the others in the circuit, the heat loss in either wire if attached as described above will be the same?

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368. *In continuation of the series of examination papers in science which was begun in February.*

Province of Alberta, High School and University Matriculation Examinations Board, Departmental Examinations, 1920.

GRADE X. BOTANY AND ZOOLOGY.

BOTANY.

Time—Two and one-half hours.

Values.

4 1. (*a*) Describe, giving drawing, the parts of a floret of any common thistle.

4 (*b*) What are the parts of a thistle head? Show by means of a drawing of one-half of the head the position and relation of these parts.

2 (*c*) What changes take place in the thistle head after fertilization?

4 (*d*) What are the leading characteristics of the order to which the thistle belongs and also the distinguishing features of its two sub-orders?

6 2. (*a*) Describe three methods by which plants ensure cross-pollination. Illustrate by reference to plants studied.

2 (*b*) (1) Give two examples of plants which depend on wind as a pollinating agent.

2 (2) State two important differences between flowers adapted to wind pollination and those adapted to insect pollination.

4 (*c*) State two important respects in which flowers determine the kinds of insects which serve as their pollinating agents. Illustrate your answer by reference to flowers studied.

6 3. (*a*) Describe an experiment to show that light is necessary for the process of photosynthesis.

3 (*b*) Show how any three of the following are adapted to secure good light exposure for their leaves: dandelion, ivy, lamb's quarters, carrot, sunflower.

3 (*c*) By reference to plants studied show how leaves have been adapted to (1) dry, (2) moist shaded, (3) aquatic conditions.

4. Write a note on the *Equisetum* (horsetail), giving:

6 (*a*) A description of (1) a fertile, (2) a sterile stem and the function of each. Give drawing of a fertile stem.

4 (*b*) The generations or stages in its life history.

OR

Write a note on the mushroom or toadstool, giving:

6 (*a*) A description, with drawing, of the mature plant;

2 (*b*) Its mode of reproduction;

2 (*c*) Its sources of plant food.

ZOOLOGY.

6 **5.** (*a*) Give a full account of the life history of a butterfly or moth that you have studied.

4 (*b*) Compare the mouth parts of the adult form with those of the grasshopper, and show the relation between the structure of the mouth parts in each case and the food habits.

2 (*c*) What are the common enemies of the insect selected in (*a*) and how is it adapted at each stage of its development for protection against its enemies?

2 (*d*) Show by reference to insects studied the difference between complete and incomplete metamorphosis.

2 **6.** (*a*) Describe, giving drawing, a typical contour feather.

2 (*b*) In what respects does a contour feather of the breast differ from that of the wing? Account for this difference.

6 (*c*) Compare the wings, bills and feet of the prairie chicken and mallard duck, and show how the differences noted are related to differences in their habits and habitats.

3 (*d*) By what distinctive features may any *three* of the following birds be identified: meadowlark, song sparrow, prairie horned lark, cowbird, killdeer, curlew?

4 **7.** (*a*) Trace the development of the frog from the egg to the adult stage.

4 (*b*) Compare the tadpole with the fish as to form, appendages and mode of locomotion.

4 (*c*) Show how it is adapted in the adult stage to either a land or a water habitat.

3 **8.** (*a*) What are the advantages of the burrowing habit?

4 (*b*) Discuss the relation between hibernation and migration and the food habits of animals.

4 (*c*) Show by reference to Alberta mammals how protection is gained through (1) coloration, (2) nocturnal habits.

SOLUTIONS AND ANSWERS.

352. *From an examination paper in Dynamics of the Scottish Universities Examination Board.*

A uniform bar, 3 ft. long and weighing 5 lbs., can turn freely about a point 11 inches from one end, and from that end a weight of 15 lbs. is suspended. From what point of the bar must a weight of 30 lbs. be suspended so as to preserve equilibrium?

Solution by R. T. McGregor, Elk Grove, California.

Taking moments about the turning point of the bar we have

$$(15\times 11)+(11/2\times 11/36\times 5)-30x-(25/2\times 25/36\times 5) = 0,$$

where x represents the distance from the turning point at which the 30-lb. weight must be suspended. Solving this equation, we find x to be 4 1/3; hence the weight must be suspended 4 1/3 in. from the turning point.

354. *From the same examination in Dynamics.*

(*b*) The Sp. Gr. of salt water being 1·04, find how much fresh water must be added to a point of it to reduce its specific gravity to 1·015.

Solution by R. T. McGregor.

Let x be the number of pints of fresh water that must be added. Then since volume = mass×density we have $1.104+x/1 = (1+x)/1{\cdot}015$. The value of x comes out 1.6; hence 1.6 pts. of fresh water must be added.

BALDWIN-WALLACE COLLEGE SCIENCE SEMINAR MATHEMATICAL PROGRAM, JANUARY 11, 1921.

DETERMINANTS, BY O. L. DUSTHEIMER.

The following questions will be considered:

1. If the third of 6 be 3, what must the fourth of 20 be?
2. To prove that 2 equals 1.
3. Thrice naught is naught; what is the third of infinity?
4. To prove that you are as old as Methusaleh.
5. Arrange the figures 1 to 9, inclusive, in a triangle so as to count 20 in every straight line. So as to count 17 in every straight line.
6. When is a number divisible by 9?
7. Write 24 with 3 equal figures, neither of them being 8.
8. If 6 cats eat 6 rats in 6 minutes, how many cats will it take to eat 100 rats in 100 minutes?
9. Can you write 30 with three equal figures?
10. Arrange the figures 1 to 9, inclusive, so their sum will be 100.
11. Can you add 1 to 9 and make 20?
12. John found $5.00; what was his gain per cent?
13. Arrange the figures 1 to 9, inclusive, in a circle, using one in the center, so as to count 15 in every straight line.
14. What is the value of 500 to the zero power? Zero root?
15. Arrange the figures 1 to 9, inclusive, in a tetragon so as to count 15 in every straight line.
16. To prove that minus 1 equals 1.
17. If a melon 20 inches in diameter is worth 20 cents, what is one 30 inches in diameter worth?
18. At 4 per cent, what would be the amount due last Christmas on $1.00 put at interest at the beginning of the Christian Era, to be compounded annually?
19. What would be the amount due on $1.00 for the same time and rate, but at simple interest?
20. Express the number 10 by using five 9's in four different ways.
21. What is a third and a half of a third of 100?
22. Do the axioms apply to equations?
23. What does a billion mean?
24. If x^2+y-11, and $y^2+x=7$, what are the values of x and y?
25. To how many decimal places has π been worked out?

CLASS ROOM SAYINGS.

Heat is formed by illuminating the cold air.

Heat is a thing used to change temperatures of a room.

Horse power is the ability of a horse to do work.

Centrifugal force is the force used only in the center of an object in pulling it.

Centrifugal force is the force existing between two objects.

The barometer always falls before a storm because the air gets colder before the storm.

The barometer falls before a storm because the air becomes heavier, thus pushing the mercury down.

Centrifugal force is the clinging together of molecules on a fly wheel.

Friction may be lessened by the use of joules.

Horse power is the amount of work in a machine which the amount of horses have the ability of doing.

A d'Arsonval galvanometer consists of a movable coil, above which a small mirror is attached to a spot of light.

A delta is a body of water at the mouth of a river where there is a depression of dirt.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS—THE RECONSTRUCTION DRIVE OF 1921.

Chemistry teachers throughout the country will be glad to know of the remarkable success attending the efforts of the New England Association of Chemistry Teachers to recover from the effects of the war conditions. From a membership of 163, this association has, in the last three months, increased its membership to over three hundred.

Although called the New England Association of Chemistry Teachers, this has been largely a Massachusetts association, its activities heretofore having been confined mainly to the vicinity of Boston. Through the successful recruiting of its membership in the other New England States, this association seems to be on the verge of a decided change in the scope of its work and influence.

At the seventieth meeting of the association held in Boston, March 5, 112 new members were voted in and the first legislative action to put these ideals of expansion into effect was taken. Unanimously, resolutions were adopted favoring and fully supporting Regional Activity.

The active work in this recent campaign has been done by the following Division Chairmen: Wilhelm Segerblom of Phillips Exeter Academy, in charge of the Northern Division, Maine, New Hampshire and Vermont; Ralph W. Channell of the South Boston High School, in charge of the Central Division, Eastern Massachusetts; J. Herbert Ward of the Classical High School, Providence, R. I., in charge of the Southern Division consisting of Rhode Island and that territory in southern Massachusetts within easy reach of Providence; and Leslie O. Johnson of the New Haven High School, in charge of the Western Division in the Connecticut valley, consisting of Connecticut and Western Massachusetts. These men, working in coordination with the Secretary of the Association, have nearly doubled the membership.

The President of the Association is Charles H. Stone of the English High School, Boston, and it is due to his sympathetic cooperation and progressive ideals favoring constructive work in the direction of expansion that these results have been obtained.

A notable feature of the work thus far accomplished is the support given by the teachers of the New England colleges. Most of the New England colleges have sent at least one teacher as a member, while in some cases, the entire chemical faculty has affiliated. This cordial spirit existing between the college teachers and the secondary school teachers certainly augurs well for the future of chemistry teaching in New England.

The next meeting is at Brown University, Providence, Rhode Island, May 7, under the auspices of the Committee of the Southern Division. A regional meeting of the Western Division has been arranged for May 14 at New Haven.

S. WALTER HOYT, Secretary,
Mechanic Arts High School, Boston, Mass.

BOOKS RECEIVED.

General Mathematics, by Raleigh Schorling, Lincoln School and William D. Reeve, University High School, University of Minnesota. Pages xvi+488. 13.5x18 cm. Cloth. 1919. $1.60. Ginn & Co., Boston.

Bulletin, 1920, No. 24, Statistics of City School Systems, 1917-18. H. R. Bruner. 477 pages. 14.5x23 cm. Paper. 45 cents. Government Printing Press, Washington.

Bulletin, 1920, No. 42, Education for Highway Engineering and Highway Transport, by P. L. Bishop and W. C. John. 134 pages. 14.5x23 cm. Paper. 1921. 25 cents. Government Printing Press, Washington.

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 30 cents a single copy. The Mathematical Supplements for 15 cents a copy.

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School Science, Vols. II and III, each	6.00
School Science, Vol. IV, three numbers	.75
School Science and Mathematics, Vols. V, VI, VII, VIII, IX X, XI, XII, XIII, XIV, XV, XVI and XVII, each	2.00
School Science and Mathematics, Vols. XVIII, XIX and XX each	2.50

ARTICLES IN CURRENT PERIODICALS.

American Botanist, for February; *Joliet, Ill.; $1.50 per year, 40 cents a copy:* "Botanizing in the Painted Desert," Willard N. Clote; "Contributions of the Plant Breeder to the Vegetable Garden," Lucile Marshall; "Plant Names and their Meanings," Willard N. Clote.

American Mathematical Monthly, for March; *Lancaster, Pa.; $4.00 per year, 45 cents a copy:* "Fifth Annual Meeting of the Mathematical Association of America," W. D. Cairns; "Acoustic Circles," H. M. Dadourian; "The Numerical Value of i^i," H. S. Uhler; "Historical Notes on the Relation $E^{-(\pi/2)}=i^i$," R. C. Archibald; "Among My Autographs," "Dupin as Secretary of the Ionian Academy," "Picard and Cassini," D. E. Smith; Questions and discussions: Questions—15, 21, 30, 34, 35, 39, 40, 41, 42; discussions—"The Theory of Perpetual Calendars," Doctor F. R. Morris; "Note on the Computation of Logarithms," A. A. Bennett.

American Journal of Botany, for January; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $6.00 per year, 75 cents a copy:* "The Fixation of Free Nitrogen by Green Plants," Frank B. Wann; "Variations in the Osmotic Concentrations of the Guard Cells During the Opening and Closing of Stomata," R. G. Wiggins; "The Linnean Concept of Pearl Millet," Agnes Chase; "The Effect of Cloudiness on the Oxygen Content of Water and Its Significance in Cranberry Culture," H. F. Bergman.

Popular Astronomy, for March; *Northfield, Minn.; $4.00 per year:* "The Problem of Mars," Hector MacPherson; "Report of the American Meteor Society for 1920," Chas. P. Oliver; "A Few Remarks on 'Dark Lightning,'" with Plates VIII, IX, X, XI, Ferdinand Ellerman; "Twenty-Fifth Meeting of the American Astronomical Society, with Plate XII," (Continued); "The Measurement of Azimuth," John G. Kellar; "Total Eclipse of the Moon 1921 April 21-22," William F. Rigge.

School Review, for March; *University of Chicago Press; $2.50 per year, 30 cents a copy:* "Studies in High-School Procedure—Mastery," Henry C. Morrison; "Junior High School Curricula and Programs," J. Harvey Rodgers; "The Schedule of Recitations," Franklin W. Johnson.

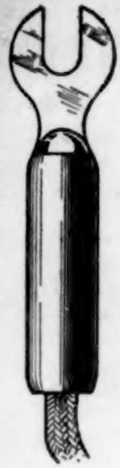
Scientific Monthly, for March; *Garrison, N. Y.; $5.00 per year, 50 cents a copy:* "The Biology of Death—The Problem," Raymond Pearl; "Hair Coloration in Animals," Dr. Leon A. Hausman; Papers presented before the section of social and economic science of the American Association for the advancement of Science: "Some Preliminaries of Peace," The Honorable David J. Hill; "War Risk Insurance," Richard G. Cholmeley-Jones; "Present Needs of the United States Patent Office," Robert F. Whitehead; "International Economic Importance of Precious Stones in Times of War and Revolution," Dr. George F. Kunz; "The Relation of Anthropology to Americanization," Dr. Albert E. Jenks; "The New Wild Life Preserve Near McLean, N. Y.," James G. Needham; "History of Biology," Lorande L. Woodruff.

BOOK REVIEWS.

Animal Husbandry, by John L. Tormey & Rolla C. Lawry, University of Wisconsin. 351 pages. 13½x19 cm. Cloth. 1920. American Book Co., New York.

This book treats on the art of breeding and the caring for farm live-stock and gives to the farmer the methods by means of which he can produce a high type of animal by the selection of proper stock feeding, and housing conditions. It tells him how to raise proper food for the stock that he is to produce; in fact, if he possesses the knowledge contained in this book there is no question but that the farmer will be able to raise that brand of stock which will bring him the highest market price at the least possible cost. In other words, he will become an efficient stock-breeder.

It is a splendid book to put in the hands of students. There are twenty-three chapters with an appendix and a very complete index. There are 118 half-tones and etchings scattered throughout the book. These are particularly selected for the points which the author wishes to bring out.



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The main paragraphs begin with bold-faced type and at the end of each chapter there is a list of practical exercises. Score cards for judging animals are put in the proper place. It is a book which demands and ought to have a wide circulation. C. H. S.

Dynamic Americanism, by Arnold B. Hall, University of Wisconsin. 335 pages. 13x19¼ cm. Cloth. 1920. The Bobbs-Merrill Co., Indianapolis.

This is a book which has a great deal of regular old-fashioned American punch in it, the author believing in an understanding on the part of our citizens of the ideals and duties of a real American democracy. The recent war afforded us a very drastic demonstration of the power and the ability of our country to organize our latent forces and put them into cooperation for the accomplishment of a great work. The author indicates that we may not always find this sentiment existing in the minds of our citizens, if we are not more fully educated in the great ideals of true American citizenship. Our youth have been educated too much in the direction of the success on the battlefield. It would be infinitely better if we could reorganize this, if we could have it centered around the ideals of the use of our powers in developing more systematically our country, as well as our ideals of morals as appertaining to the true development of manhood, and this book has been written very largely with this point of view in mind.

There are twelve chapters in the book with a bibliography at the end. Suggestive questions are found at the end of each chapter. It is printed on uncalendered paper in ten-point type. It is thus easy to read. The diction is splendid, the matter interesting and it is a book that every true American citizen should read. C. H. S.

The Hand Book of American Private Schools, Porter E. Sargent. 848 pages, 13×19 cms. Cloth, 1920. Porter E. Sargent, 14 Beacon St., Boston, Mass.

Without question this is the most complete book of American private schools ever published. It is a book that all parents, contemplating sending their children away from home to school, should possess, as all of the essential points pertaining to practically every private school in the country are contained within the covers of this book.

Likewise, it is a valuable book for all superintendents and principals of high schools, especially, to possess, from the fact that it is an encyclopedia on the many phases of secondary school work. It gives a summary and a large mass of facts pertaining to secondary school work. There are also many pages devoted to the progress of education in the years 1919 and 1920, the high points being clearly presented. Likewise the epitome of what colleges are doing is presented. Educational literature also has a place in the book.

Private schools for both boys and girls are clearly described. This matter is taken up by states, making it very easy to find any school in which a person may be interested. There is an alphabetical list of private schools for both boys and girls presented which not only tells one the name of the school, but its location, principal or head master, the price per year for tuition and board, when established, the faculty and enrollment.

Information, too, is given for schools of music, art, kindergarten, for the deficient, for lip reading, business schools, boys and girls' camps, etc. There is an alphabetical list of firms and agencies who deal either directly or indirectly with schools in all of their various phases. A splendid list of educational associations is also given. Educational foundations, year

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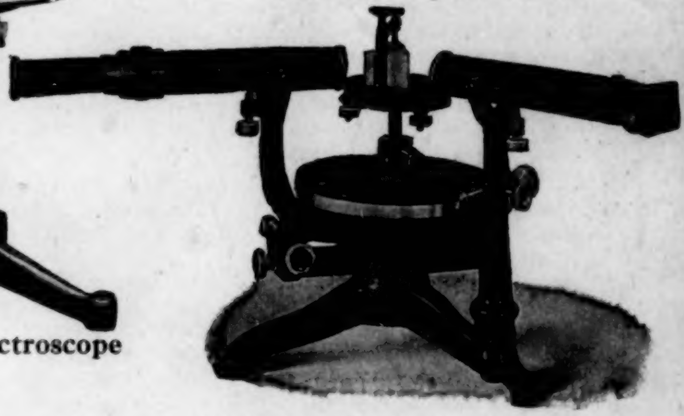
L201
Student's Spectroscope



L101
Student's Spectrometer

These instruments, in their elegance, simplicity and precision of workmanship, set a distinctly American mode in instrument-making, embodying, as they do, the best in foreign practice, along with the utmost of worth-while individuality that the maker's many years' experience has been able to contribute thereto.

These Spectroscopes and Spectrometers are made also in models of greater precision for special use, and amongst these others we look forward to completing, during 1920, our New Wave Length Spectrometer, advance orders for which will be filled in rotation as received.

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books, and educational periodicals are listed. Publishers of educational books are mentioned.

There are many pages devoted to school and camp announcements, many of the schools being prefaced by views of the school. In fact it is an encyclopedia of secondary school information. Some idea of the extent of the work may be gathered from the fact that there are 47 pages devoted to the index. This book deserves a very large circulation among school men and parents who have children to educate.

C. H. S.

Principles of Human Geography, Ellsworth Huntington, Yale University, and Sumner W. Cushing, Normal School, Salem, Massachusetts. Pages xlv+430, 15.5×23 cms. Cloth, 1921. John Wiley & Sons, New York City.

The fundamental principle of this book is to present geography from the human point of view, and to provide a book easily taught, giving a comprehensive view to the pupils who have reached that age when they begin to think for themselves; and especially for normal school students where they will be able to secure that knowledge necessary to present the really human side of geography which they expect to teach.

The author first takes up the physical aspect, giving to the reader an outline of the work, if he expects to pursue the subject farther. The book differs from others a good deal on its dealing very largely with human relationships, and second with the influence which climate has upon the physical and meteorological phase of the subject.

The book consists of 22 chapters, has 118 splendidly selected cuts and half-tones made largely for the work. The major paragraphs begin with bold-faced type and give a key to the subject matter in those paragraphs. Questions apropos to the subject are given at the end of each chapter. There is a splendid two-column index given in the appendix. The book is printed on a high-grade calendered paper and is a book that all teachers of the subject should possess.

C. H. S.

Elementary Home Economics, Mary L. Matthews, Purdue University. Pages xx+343, 13×19.5 cms. Cloth, 1921. $1.50. Little, Brown & Co., Boston.

This book is without question one of the best that has recently come from the press discussing the problems of home economics. There are many new features in connection with it. It is written in a clear, understandable manner, the main part of the book being printed in 10 point type, the explanatory paragraphs, problems, and questions in 8 point type. It has been arranged to be used in the elementary schools and requires but very little training on the part of the pupil, in general science.

The book is divided into two parts; the first treats of sewing and textiles; the second foods and cookery and the care of the house. In part one a discussion of how garments are made and lessons in the nature of various textiles is given. The important point of the hygiene of clothing is likewise splendidly discussed here. Part two deals with foods, their selection, preparation and planning of meals from the balanced ration and economic point of view. The work is discussed really around the project called, "The Meal Plan." The book can be nicely used in those schools where one text book must cover the course. The book is well illustrated with half-tones taken from real life. These cuts, however, do not show up as well as they should on the quality of paper that is used. The paper is partially calendered, thus reducing the direct reflection of the light to a minimum. Mechanically, the book is well made, and will stand strong usage.

C. H. S.